NATURE

No. 4029 SATURDAY, JANUARY 18, 1947 Vol. 159

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The annual subscription rate is £4 10 0, payable in advance, inland or Abroad

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RESEARCH ASSOCIATIONS IN GREAT BRITAIN

IN reply to a question in the House of Lords on December 4, Lord Chorley stated that preliminary discussions had taken place with the wool, building, iron-foundry and silk industries regarding the use of the Defence (Services for Industry) Regulations, 1945, to further industrial research. In general, the development of arrangements of this kind had awaited the reports of the Working Parties set up by the Board of Trade, and all the reports so far received recommend the use of a compulsory levy to support scientific research. He stated that the proposals of these Working Parties on this, as on other matters, would be dealt with under the legislation announced in the King's speech, and which was intended to supersede the Defence (Services for Industry) Regulations.

This statement will be regarded with some uneasiness by most of those concerned with research, whether on the industrial or the scientific side. Of the Working Parties which have already reported, only those for the pottery and the cotton industries showed clear conceptions of the nature of research, and it was the latter report which, recognizing that the research associations had important functions to perform as central research institutes, suggested that it would be useful to review the experience of the whole research association movement. Since that report appeared, those from the Working Parties for the boot and shoe industry and the furniture industry have emphasized the soundness of the judgment of the Cotton Working Party that the right answers are not yet clear to such questions as the nature and scope of the functions of a research association, how they can best be exercised, by what means their exercise can be made of the fullest possible value to industry and how they should be correlated with the functions of individual firms.

The report from the Pottery Working Party in general supports this attitude, although it was concerned rather with one particular research association than with the general question. None the less, it points out that dissatisfaction with a research association might be due to a false conception of its proper functions, and that any vigorous industry with private research establishments moves rapidly ahead of its co-operative research association in knowledge of the application of scientific work. Furthermore, the Pottery Working Party points out that day-to-day problems requiring investigation can be dealt with much more easily and effectively by a competent technical manager or research staff in the factory itself, and it recommends firmly that the research association itself should distinguish its day-to-day technical consultation from its fundamental research, and should on no account fail to make provision for the latter. Finally, after admitting that a very small levy for co-operative research may be a proper charge on every substantial firm in the industry, particularly if a research association limits its work to fundamental problems, it is reiterated that a research association cannot justify itself until

an adequate body of research workers is employed privately by manufacturers to form a bridge between the association and the industry.

No such clear conceptions characterize the report of the Working Party for the furniture industry. It is admitted that the industry in the past has paid insufficient attention to research, that the vast majority of the firms have no research organisation within their factories, and that this neglect has been one of the causes of the stagnation in design. It is recommended that a research association for the industry be established, and also that individual firms should, wherever possible, set up their own research units; but the functions suggested for the proposed research association demonstrate a very inadequate conception of research. The research association, it is suggested, should have as its main functions the formulation of the industry's research problems, and undertaking them or placing them with appropriate outside organisations. Next, it should take steps to bring to the notice of the industry the results of all research work undertaken on behalf of the industry. It should also be responsible for examining scientific publications for information likely to be of interest or of use to the industry, and for bringing such information to the attention of its members. Finally, the research association should be responsible for running the independent testing station connected with the proposed minimum standards scheme, as well as for carrying out the research required to establish standard performance tests.

The contrast between these views and those urged by the Pottery Working Party is seen finally in the contention by the Furniture Working Party that the function of a research association is primarily technological and secondarily 'fundamental'. Admittedly the Furniture Working Party was concerned with an industry where the organisation and equipment for research have largely to be established, and it rightly has in mind the possibility of utilizing the existing laboratories and institutions of the Department of Scientific and Industrial Research, for example, the Forest Products Research Laboratory and the textile research associations, especially while the new association is formulating its programme and building up its own facilities. The formulation of a research programme is the first stage, but is largely a matter for the industry itself; and only when such a programme has been formulated at least in broad outline can it be clearly seen what contribution a research association could make, how far the problems to be solved involve co-operative effort and investigations into the fundamental sciences on which the industry must draw, and what facilities must be provided to supply those needs.

No definite proposals for financial support of a research association can well be put forward until a research programme is available, and this is all the more important in an industry which relies so much on tradition. Here the experience of the building industry, another 'traditional' industry, may prove of some help. What must be remembered is that an educational campaign will be necessary to secure the requisite support for a research association scheme. To inform the industry is a first task, and although an information department is an important and indeed essential element in the working of a research association, its functions must be directed primarily to the service of the research department's own needs and not to the broadcasting of information to the industry as a whole. The task of extracting and circulating items of interest from published information requires the help of information officers, if not sections, within the individual firms themselves, and until firms are equipped, at least by the presence of sufficient scientific and technical men and women on their own staff, to utilize the available information presented to them, the efforts of a research association in selecting and circulating such material are likely to be of little value. This preliminary task of education is of fundamental importance.

In an article on "Cultural Understanding and Appreciation of the Scientific Approach" in *Science* of October 11, 1946, R. H. Ojemann makes a point which is often overlooked in this connexion. He presents evidence that the function of research is not well understood either by leaders of the community or by students leaving school, and although he is concerned primarily with the fact that research is not in consequence considered as an important function in society or regarded as a valuable method of solving social problems, his main point is of wider significance; namely, the absence in the community of sufficient knowledge of the nature of scientific research, of the probability character and limits of knowledge, and of the constant changes in our knowledge, constitutes a grave danger to the support of scientific research in a democratic society.

While this condition obtains, there is not only difficulty in obtaining adequate support for research, but also a continuing risk that such support may be suddenly and capriciously withdrawn. The bearing of this on what may be termed scientific information services is rarely appreciated. The dissemination of information is commonly directed to the circulation of information on scientific findings. Too few attempts are made to promote understanding of how dependable knowledge is obtained, what it costs in effort, as well as money, to establish scientific results, and the handicaps imposed by the present limits of knowledge.

It is on such points as these that the educational work preceding the establishment of a new research association should be concentrated; if more effort were directed to such ends rather than to the mere dissemination of scientific knowledge, we should be nearer to finding the right answers to the questions emphasized by the Working Party for the cotton industry. Moreover, the research associations themselves would be in a much better position to make their full contribution to industrial efficiency; and they should in fact become the more conscious of their great responsibilities so long as misconceptions persist in the community as to the contribution which research can offer to the solution of such problems as the housing shortage, the coal shortage, or the

restoration of the cotton industry to a condition to meet future world competition.

There is, in fact, no need for the research associations to adopt the defensive attitude which characterized contributions to a recent conference in Manchester on "Research and the Smaller Firm". Co-operative research on certain aspects of industrial problems needs no defence. The universities should not, and the Government laboratories cannot, engage in research work of the usual *ad hoc* industrial type, which has as its prime motive the desire of the participating firm to increase its competitive position. But the research association is only one of the ways in which industrial research can be prosecuted, and indeed depends for its full effect, as the Working Parties have realized, upon the existence of active research departments in the individual firms themselves.

There is here another factor to be considered. While there may be other means to be explored besides the research association method for prosecuting research which a firm has neither the staff nor the equipment to carry out in its own laboratories, there is an undoubted *prima facie* case for pooling resources in a central research association for ambitious, long-term projects of fundamental and probably highly speculative type. In order to gather the full fruits of such pooling, however, the central research body must be competent to conceive and plan the approach to targets in such fundamental research; and the subscribing firms must be provided with research units at the points of production, so as to facilitate the proper application of the results.

Now in industry the ability to plan successfully long-term research has only evolved gradually, from experience in the conduct of less ambitious projects. If, therefore, a research association is to plan such research, and select appropriate objectives and the men to carry out the projects, leaving them to carry out their investigations with the minimum of interference or 'management', it will require to be as strong on its technological as on its scientific side. Here lies the critical problem before the research associations to-day, namely, commanding the services of research workers of the requisite experience, energy and creative powers. It is a question of man-power, of having available scientifically and technically educated men capable of taking the highest positions in each of the three primary functions of industry—research, production and selling.

That much has been clearly grasped by the Working Party for the jewellery and silverware industry. While its comments on the indifference or even hostility of the industry to research and design, and its recommendations regarding its proposed design and research centre, which the Board of Trade and the Department of Scientific and Industrial Research are already engaged to support, are broadly parallel with those of the Furniture Working Party, this report proceeds: "It is also plain to us that the close and sensitive contacts required between the Centre and the many firms engaged in commercial production will not be established and maintained, unless a good number of these firms can be induced to recruit and absorb men of broad scientific education and wide technical training in positions of good standing".

No Working Party has yet stated explicitly, however, that the criterion of progressive industry is the ability at board level to direct its research work with the same acumen and efficiency as are applied to production and sales. On this point it might be suggested that leaders in some of the industries which have hitherto been unmindful of research might study with profit the early history of such an industry as the dyestuffs industry, in which research is admittedly a keystone in its structure. It is probably with the idea of assisting in training men with a scientific outlook and experience in research, and the permeation of industry with them until they reach the top, that the Cotton Working Party was led to recommend the establishment of industrial research fellowships and associateships, a plan for which was set forth in some detail in an annexe to its report. The ultimate object of the scheme is to establish a body of experienced research workers within the industry itself, although it visualizes a research foundation having on its staff research fellows and associates whose services could be made available to firms requiring them.

While it is essential for the research associations themselves to secure both an inflow and an outflow of trained research workers, moving between the associations and the industries they serve, there is little evidence in current discussions that either the research associations or the Department of Scientific and Industrial Research are sufficiently alive to the importance of this matter. To accelerate the training of such men and to facilitate the permeation of industry by them are the vital tasks: a system of liaison officers is dilettante trifling with the issues. The Department of Scientific and Industrial Research has indeed already assisted many science graduates of the universities to undertake the post-graduate training which should fit them to undertake research; but there is still much to be done on these lines before the status of some of the technical faculties is raised to that of research schools. If the Department, through its research associations and in other ways, is prepared to assist such developments and to try new ideas and new methods, it will promote a flow of men with a research outlook and a technical background, it will bring new knowledge to the technological field, and will also infuse new vitality into the research associations themselves and place them on the firm foundation of proved service rendered to the industries with which they are linked. Every consideration which increases the importance of a wise and efficient use of our limited resources of scientific man-power makes it the more imperative that, before any large new schemes involving the employment of numerous scientific workers either in research or in other capacities are launched, we should do our utmost to expedite this interchange between industry and the universities and other institutions where fundamental research is pursued. In this way we can ensure that industry is fully prepared to utilize the new knowledge which a new organisation might provide.

SCIENCE AND STOCKBREEDING

Animal Breeding

By Dr. A. L. Hagedoorn. (Agricultural and Horticultural Handbooks.) Second edition. Pp. 304+15 plates. (London: Crosby Lockwood and Son, Ltd., 1946.) 15*s*. net.

The Milch Cow in England

A Plea for Constructive Breeding. By E. R. Cochrane. Pp. 348+16 plates. (London: Faber and Faber, Ltd., 1946.) 16*s*. net.

DR. HAGEDOORN'S book is a second edition of one first issued in 1939, reprinted four times, and now emerging as a further contribution to the field of genetics applied to livestock improvement; Miss Cochrane's is an entirely new analysis of problems of cattle-breeding in Great Britain. The texts are alike in that they are intended to stimulate, and the authors' techniques are somewhat similar in that they both attack some of the vested beliefs and interests in stockbreeding and, rather unfortunately, find it necessary to repeat statement and argument too much and too often. But there resemblance ceases, and the effects of the stimuli differ; Dr. Hagedoorn sets out to be educative and ends in being provoking, Miss Cochrane to be critically provocative and becomes distinctly educative.

Moreover, the authors' backgrounds are in great contrast. Dr. Hagedoorn has come by what might fairly—nowadays—be called the easy road to an exposition of applied genetics: from small-animal breeding, via poultry, past some view-points of possible applications in the larger animals to a stance from which an almost complacent dogmatism can be readily enunciated for the benefit of stockbreeders and students eager to add something from the new science to the old art. The process of instruction is to some extent simplified, if the results of recent work and their implications are not appreciated; and the clarity of presentation becomes more superficial. Now, in one sense Dr. Hagedoorn has served a useful purpose. In 1939 there were few simple texts available to arouse the practical man's interest in applied genetics, and his almost conversational, almost inconsequential, style held attraction to the acquisitive reader. His book was, is, and this new edition no doubt will be, widely read. There lie the dangers.

Even allowing for the difficulties and the distressing isolation under which Dr. Hagedoorn has pursued his own work since 1939 (and from which we, together with many other animal breeders and geneticists, welcome his safe reappearance), it must be said fairly that the slight annotations by which this edition differs from the first do not remove its weaknesses, confusions and misleading statements. These are too numerous to specify here; however, the insistence on the presence and absence idea was inept even in 1939, and to use the reduction in number of ancestors as a measure of inbreeding is outmoded, to say the least; the discussion of domestication and adaptation is confused and not always plausible. Further, the author's own arguments for progeny-testing and his 'nucleus scheme' of breed improvement on the basis of genetic uniformity are not very convincing or acceptable, and should be re-examined in the light of recent genetical work and practical requirements. Dr. Hagedoorn's text, therefore, provokes not only criticism at many points but also serious concern that, having been widely read, it has apparently been accepted by many readers as a completely authoritative statement of modern genetics in relation to stockbreeding.

Fortunately, Miss Cochrane is not one whose approach is limited to that signposted by Dr. Hagedoorn. She has come by the hard road from dearly bought experience in pedigree cattle-breeding, through the doubts and disappointments of hoping that pedigree and practice might give performance and efficiency, to a point at which a critical exploration of many routes was needed. She has obviously made wide reconnaissance of the possibilities of collecting material for a sound path for the future from the fields of physiology, economics, nutrition, genetics and practice. Here is a frankly personal, often outspokenly critical, but always well documented, inventory of what she has found so far and hopes may come.

The result is extremely provocative; the reactions are bound to be varied in intensity as well as kind, according to the reader's vested interest or predilection. But surely, no matter how annoyed, disturbed or sensitive, no one should accuse Miss Cochrane of complacency, of intellectual dishonesty, or of narrow-mindedness, except in so far as she is determined to improve the average cow of the average breeder in England (and Scotland and Wales and everywhere!), perhaps too quickly, but ultimately. No two readers will agree. Her own criticism is given, so that she obviously invites it, in her turn, especially if it can be constructive and would help her to rewrite in some future edition the last three chapters ("Enterprise and the Breeder"; "Security and the Farmer"; "The Responsibility of the State").

Unity of aim, absence of humbug and close co-operation of scientific workers, administrators, breed societies, breeders and the State, she sees as essentials towards the establishment of a sound progressive (*not* static), efficient and satisfactory cattle industry. We are confident that Miss Cochrane herself would be well satisfied if she could find the average great-great-granddaughter of the present average English cow a higher producer of a better quality milk over a longer, healthier life-time, even if she had to withdraw some of the contentious and perhaps extravagant conclusions she now makes. Meantime, we feel that the almost impetuous presentation of the case should not be met with any impetuous reaction, but should be widely read and considered as indeed "a plea for constructive breeding".

J. E. NICHOLS.

METALLURGICAL ATOMS

Atomic Theory for Students of Metallurgy

By Dr. William Hume-Rothery. (Institute of Metals: Monograph and Report Series, No. 3.) Pp. viii+286. (London: Institute of Metals, 1946.) 7*s*. 6*d*.

"EXPERIENCE has shown," Dr. Hume-Rothery cautiously remarks, as though introducing a statement which would arouse incredulity, "that students of metallurgy are greatly interested in the new theoretical work [on the structure and properties of metals and alloys] but are often quite unable to understand the papers or text-books written by mathematical physicists." In this book, therefore, he has attempted to provide a bridge by means of which the student of metallurgy may be led to an understanding of the general ideas on which the

modern theory is based. He can be assured that students of metallurgy, though they may sometimes suffer from the peculiar disadvantages of unimaginative and narrowly conceived technological types of training, are not alone in their misfortunes. An easy path through difficult terrain is likely to be gratefully used by many others than those for whom it was primarily made. The path here is skilfully constructed, and it affords an admirable view of many of the most interesting superficial features of the region, as well as occasional glimpses of details of the underlying structure.

The book gives the most comprehensive survey of the modern electronic theory of metals that has yet been made with so limited a use of mathematical technique and symbolism. The thirty chapters are grouped in six parts, the first three of which, dealing with the general background, the structure of the free atom, and assemblies of atoms, outline the basic atomic theory. After a very brief review of the classical and the original Bohr theory of atomic structure, the presentation is almost entirely from what may be called a descriptive wave mechanical point of view. Considerable attention is given to methods of representation of electron-cloud density, and when 'pictures' of atoms are given, their limitations are adequately stressed. There is an excellent chapter on the soft X-ray spectra of solids, a field of investigation the potential importance of which is not yet widely appreciated. This first half of the book may be commended to all those who wish for a non-mathematical introduction to modern atomic theory. Only occasionally is there a looseness of phraseology, to which the supersensitive might make the objection that a wrong impression could be conveyed. It will be sufficient to give, without comment beyond italicizing, one example taken from p. 52, where it is stated, "It might at first be thought that the normal state of every atom would be such that all the electrons occupied the lowest quantum state. Actually, however, this is not the case, *owing to the effect of* what is known as the Pauli Exclusion Principle."

The second half of the book is concerned with the application of the general ideas to the theory of metals. Fermi–Dirac statistics and the free electron approximation are described, and a good general account is given of the Brillouin zone treatment. In the last part a systematic survey is made of the bearing of the theory on the interpretation of the properties of the metals of the first column of the periodic table and their alloys, of representative metals of higher valency and crystal structures other than cubic, and of the elements of the first transition series. Sections are included on a number of special topics, among them being specific heat, Pauling's theories, and electron bands in iron. The concluding chapter gives a brief account of magnetic properties. Throughout this part of the book the author's discussion and assessment of the achievements of wave-mechanical theory is of particular interest and value owing to his wide and detailed knowledge of alloy systems, to the clearer understanding of which his own work has contributed so substantially.

Almost every paragraph of this book bears evidence of the care and thought which have been expended to write of the basic ideas of wave-mechanical theory and of its application to the interpretation of the properties of metals in a way that shall be intelligible to an honours student of metallurgy of limited mathematical attainments. The author has carried out admirably the plan he seems to have had in mind, and for this reason the book is rightly assured of a wide welcome.

The book should not be regarded as a substitute for the more mathematical text-books, but rather as a commentary on them. It would be most unfortunate if a student of metallurgy, or any other reader, were to gain the impression that an understanding of the essentials of the quantum mechanical theory of metals could be gained by a perusal of this book alone; yet there is practically no guidance, even by reference, to the now fairly numerous good text-books on the theory of a more mathematical but still fairly elementary character. Hume-Rothery, in attributing the inability of the student to understand such books to "the failure of the mathematician to appreciate the difficulties of the non-mathematical reader", overlooks two much more essential points: first that it is the physical world which it is so difficult to understand, and second that the nearest approach to understanding is that provided by a theory which is most conveniently expressed in mathematical language, and which must be so expressed if effective development is to be possible. Those who wish to understand the theory must be prepared to make the effort necessary to acquire at least a reading knowledge of the language. They should not be led to suppose that an appreciation of some of the highest flights of human genius in the scientific exploration of the world can be gained by an approach as effortless as might be required for 'a bed-time story for tired metallurgists'. This book is certainly no bed-time story, but it does share some of the characteristics, including the good ones, of a Lamb's Tale. It may well have been thought that the title would indicate sufficiently the degree of adaptation.

E. C. Stoner

NUCLEAR PHYSICS

Fisica nucleare
Dalla pila di volta alla pila atomica. Per Plinius Campi e Aldo Rusconi. Pp. viii + 215. (Milano: Ulrico Hoepli, 1946.) 400 lire.

La scissione nucleare dell'uranio
Fenomenologia generale. Per Dott. Emidio Prata. Pp. 160. (Milano: Ulrico Hoepli, 1946.) 250 lire.

THE arrival of scientific books from Italy is a welcome sign of the return, in some measure, to more normal conditions in scientific life. It is apparent that the production of the two books under review must have represented a considerable effort in the face of shortages.

It is therefore particularly sad to discover that the contents of the book on nuclear physics are scarcely worth such an effort. The authors deserve congratulations for the ingenious sub-title: "From the Volta pile to the atomic pile", but the praise has to end there. Between the first chapter on Volta (which does not explain Volta's pile) and the last one on atomic energy (which contains a very misleading account of the atomic pile and atomic bomb), an assortment of chapters, some philosophical, some popular descriptions, range over a variety of subjects. Mixed up in them is a new theory, due to one of the authors, according to which space consists of points and antipoints; this theory, we are told, leads to a geometric interpretation of quantum mechanics. A large number of minor and major errors indicate that

the authors are not too familiar with modern theoretical or experimental physics.

Dr. Prata's book on fission is on a different level altogether. It attempts to summarize the work published on this subject up to 1943, to which is added a brief abstract of the Smyth report. While the preface does not explain the history of the book, one gains the impression that the manuscript must have been ready some time before the news of the atomic bomb was released, and that the final chapters were added later. However that may be, this book is not one of the many superficial accounts that are trying to exploit the publicity value of atomic energy; it is a serious piece of work intended for the physicist who has kept up to date in modern developments and wants to collect the information on fission without going through all the original papers. A first historical chapter reconstructing the steps leading to the discovery of fission is followed by chapters on fission products, on the energies and masses of the fragments, their passage through gases. A chapter on the theory gives a very readable account of the stability calculations and an outline of the Bohr–Wheeler theory which is somewhat less successful. A chapter on secondary neutrons, a brief mention of Feather's proof of instantaneous fission, and a discussion of data on cross-sections conclude the review of the older literature. The rest of the book consists of a short summary of the Smyth report on the American project, and an almost complete bibliography up to 1943.

This bibliography and the comparative discussion of the early papers will remain useful even though the release of American, British and Canadian work from secrecy is bound soon to make this book obsolete as an account of current knowledge. The author has missed a few points in the Bohr–Wheeler theory and one or two major ones in the Smyth report, but otherwise the book is instructive, and, for the physicist with some knowledge of nuclear physics, very readable.

R. E. Peierls

BIRDS OF NORTH AMERICA

Audubon Bird Guide

Eastern Land Birds. By Richard H. Pough. (Sponsored by National Audubon Society.) Pp. xxxvii+312+48 plates. (New York: Doubleday and Co., Inc., 1946.) 3 dollars.

ORNITHOLOGICALLY speaking, North America is divided into four areas—western, eastern, middle America and the West Indies, the largest being the eastern one that includes the Atlantic seaboard. Mr. Pough writes of the birds of this area under the title of "Audubon Bird Guide—Eastern Land Birds". He deals with the 275 species of land birds found in eastern North America in a concise manner, most helpful to the recent recruit to ornithology. His remarks under the heading of "Identification" are excellent, for he seizes on the outstanding characteristics of each species and tells the field worker what to look for. The colour portraits are also good and helpful, though it is to be regretted that no indication of scale accompanies them. If one did not know otherwise, one might imagine that the snowy owl is no bigger than the English sparrow, the picture of which is most life-like; however, in most cases all birds on a plate are drawn to the same scale.

The foreword will be read with appreciation by ornithologists of both New and Old Worlds, for it contains much of interest and many practical common-sense hints for the beginner, also he who no longer comes under this heading. The remarks on psychology and behaviour give food for thought. "The study of birds has been greatly handicapped by a tendency to interpret their behaviour according to human standards. This is a mistake. Birds are creatures of instinct, and the whole pattern of their lives is determined in advance by their inheritance. They have no power of thought as we understand it. Apparently a newly hatched bird inherits everything it needs to carry out every step in its life cycle, even when it includes long migration flights, elaborate nest-building, or any one of hundreds of other equally complex performances." The author goes on to say, "Birds are no less fascinating because they act like automatons; that is, like birds instead of people".

Although Mr. Pough is certainly correct regarding the birds' inherited patterns of behaviour, maybe his generalizations are somewhat too sweeping. For example, anyone who has had dealings with a tame raven will find it difficult to dispense with the word 'intelligence' in any analysis of its conduct. Is it automatonism when it tweaks the cat's tail?

Frances Pitt

PLANT TISSUE CULTURE

Une voie nouvelle en biologie végétale

La culture des tissus. Par R.-J. Gautheret. (L'Avenir de la science, No. 21.) Pp. 202+32 plates. (Paris: Libr. Gallimard, 1945.) 190 francs.

THE technique of culturing animal tissue *in vitro* has, on many occasions, received considerable publicity. No comparable public interest has been centred on the cultivation of plant tissues, yet in many ways the results have been at least as important. In animal tissue culture the media used have normally contained tissue extracts and serum, and attempts to produce purely synthetic media have so far met with little success. Media used in plant tissue culture, on the other hand, have in the main been synthetic, and it is not surprising, therefore, that successful continued proliferation of undifferentiated plant tissues *in vitro* have been achieved only within the last eight years. Most of the successful advances have been made in France or the United States, and in the former country the technique has been developed primarily by R.-J. Gautheret. It is, therefore, with considerable interest that one turns to his account of the subject.

After a historical introduction, the writer discusses the principles and problems of the techniques used, and then goes on to consider the morphological characters of the cultures obtained. Chapter 4 deals with the problems of the physiology of the growing tissues, and the final chapter with the possibilities of the technique.

The account of the methods and results is admirable, and the work is well illustrated with excellent plates and good figures; but the deliberate omission of references detracts considerably from the book and tends to damp interests stimulated by the text. Gautheret has made it abundantly clear that the cultivation of plant tissues has immense possibilities, and although many difficulties remain to be surmounted the future of the technique is assured.

Alan Burges

HISTORY OF ALCHEMY AND EARLY CHEMISTRY*

By PROF. J. R. PARTINGTON, M.B.E.
Queen Mary College, University of London

THE history of alchemy should properly begin with a survey of the technical arts of the ancient nations. Archæological discoveries show that these arts were highly developed about 3500 B.C., so that they must have arisen earlier. Later on they declined, and in Egypt, by the beginning of the Christian era, had mostly deteriorated into an imitative technique, although in some cases, as in the manufacture of glass, there had been advances. The precious metals and gems had been replaced by base alloys and coloured pastes.

Alchemy is a growth which appears suddenly in Egypt about the beginning of the Christian era, and at first sight seems to have no roots. Its origins were long surrounded by a veil of mystery. Its earliest name, the 'Divine Art', points to its supposed origin in a divine revelation by fallen angels, a tradition embellished in Jewish works like the Book of Enoch, and in some Greek alchemical texts. In the latter, it also appears as a revelation by the god Hermes Trismegistos, the Hellenistic form of the ancient Egyptian god Thoth, and hence alchemy was sometimes called the 'Hermetic Art'.

In its earliest period, and for long afterwards, alchemy meant the practical art of making gold and silver. It had also certain theories, or dogmatic rules, the most important being a belief in the essential unity of matter, and the possibility of converting one form of matter into another by suitable treatment. These theories originated in the speculations of Plato and Aristotle.

The view that the chemical elements are permanent and unchangeable was only generally adopted, on an experimental basis, at the end of the eighteenth century, the possibility of transmutation having been accepted, for example, by Boyle and Newton. The doctrine of the permanence of the elements was a necessary step in the development of chemistry, and the alternative view could not receive any experimental basis until quite recent times.

The atomic theory, another achievement of Greek genius, is unfavourable to alchemy, since it pictures the elements as aggregates of particles of different species which are permanent for all time; and it is noteworthy that the early alchemists make no use of it. Although Demokritos, the founder of the atomic theory, may be said to be also the founder of modern chemical theory, the master of the alchemists was Plato.

So far as is known, Western alchemy arose about the beginning of the Christian era in Alexandria, from the joining of two streams of knowledge; the first of these was the ancient Egyptian art of working metals, and the second the theoretical views on the nature of matter taught by Greek philosophy.

In A.D. 296 the Roman Emperor Diocletian issued in Alexandria an edict ordering the books of the Egyptian forgers teaching the preparation (that is, imitation) of gold and silver to be burnt whenever they could be found. One such book appears to be the Papyrus of Leyden, found in 1828 buried with a mummy in Egypt. It was written in Greek about Diocletian's time, and contains the working notes of a fraudulent goldsmith. It deals with the imitation of precious metals so as to 'deceive the expert', as it says, including the plating of copper or silver with gold (by treating with gold amalgam and heating to drive off the mercury), and with making imitation silver from tin. Another part of the same work, the Stockholm Papyrus, treats mostly of the imitation of gems and valuable dyes, such as purple. Some Assyrian cuneiform tablets of 650 B.C. also describe the imitation of lapis lazuli by blue glass coloured with cobalt, some specimens of which have been found.

In these papyri there is no suggestion that the products were more than clever imitations. Alchemy, which assumed that real gold and silver could be obtained, arose from Greek philosophical ideas. These, as understood by the alchemists, postulated a primary matter, or *hulē*, on which a form, or *eidos*, could be impressed so as to give a specific body such as lead or gold, which was an association of primary matter and form. If lead could be divested of its specific form, and the form of gold impressed on the primary matter (the same in lead and gold), then gold would result.

A subsidiary idea of Chaldæan and Persian origin supposed that metals are formed in the earth by the action of rays or effluences from the seven planets, each producing a particular metal. Astrology, which has been described as an organised body of error, thus became the sister of alchemy; but in practical alchemy its influence was mainly confined to the use of the planetary names and symbols for the metals: gold and the sun, silver and the moon, copper and Venus, and so on.

Suitable starting materials for transmutation were supposed to be lead, which was easily 'mortified'; or a yellow alloy of lead and copper (a lead bronze, known in ancient Egypt and Babylonia), called *molybdochalkos*; and also mercury, since Plato had taught that metals are formed from water, and this *hydrargyros*, or silver-water, was thus very near the primary matter of metals.

The earliest alchemical texts are in Greek, and go back to the first two or three centuries A.D. In them the subject is called the 'Divine Art'. The name 'chemistry' (χημεία) came somewhat later, about 300 A.D. It is probably derived from the old name for Egypt, *Chem*, found in hieroglyphics and known to Plutarch, which means black, from the black colour of the alluvial soil. The texts abound in obscure words, and what is worse, in common words used in a very uncommon sense. We are told to take "the bile of the serpent which is the divine water"; but in another place this is said to be made by boiling sulphur with milk of lime. The divine water (θεῖον ὕδωρ) is a solution of calcium polysulphides.

The earliest author is Demokritos—not the old Greek philosopher, Demokritos of Abdera, but a writer of the first century A.D. His main work, "Physical and Mystical Matters", begins with some recipes for imitating purple in the style of the Stockholm Papyrus, but suddenly breaks into a story of an invocation of the shade of the dead master, the Persian Ostanes, and the subsequent discovery of an inscription revealed by the opening of a pillar in a temple. This inscription merely said: "Nature rejoices in nature, Nature conquers nature, Nature overcomes nature". "We were much surprised," says Demokritos, "that he had comprised all his teaching

* Based on three lectures at the Royal Institution on October 31, November 7 and 14, 1946.

in so few words." These words may express the fundamental alteration of specific property (φύσις, nature) by what Aristotle had already recognized as chemical change, and distinguished from mechanical mixture. No chemical apparatus is described.

Two other early authors are Maria the Jewess, probably a real person from Jerusalem, and Cleopatra the Egyptian, who is otherwise known as a writer on weights and measures and on cosmetics. Maria, probably in the first century A.D., invented the earliest apparatus for distillation, and an instrument called the *kerotakis*. The *ambix*, used for distillation, was originally a kind of spouted jug. She describes the making of an *ambix* from thin sheet bronze, "in thickness little more than that of a frying pan for cakes", comprising a vertical tube, a head, and three outlet pipes, all carefully soldered. This piece, later called the helm or head, was luted to a glass or earthenware body, called a *lopas*, later called the *cucurbit*, or *aludel*, and the whole was heated by lamps or a small fire, the products of distillation being received in small phials. The *kerotakis* apparatus comprised a small brazier such as was used by encaustic painters for keeping the coloured wax melted (hence the name), and a small heated plate with cup-shaped depressions, such as was, and is, used for cooking eggs, but was probably the palette used by encaustic painters. The apparatus was used for sublimation, the vapours being condensed on a small bell-jar inverted over the palette. So cinnabar was made by sublimating sulphur and mercury, white arsenic obtained by roasting the red and yellow sulphide minerals, and called 'white alum'; the element arsenic itself was formed by reduction, and called the 'second mercury'.

Cleopatra's work, called the "Chrusopoiïa", or the making of gold, is a page of symbolic drawings. The dragon Ouroboros, engaged in eating his own tail, surrounds the legend: ἕν τὸ πᾶν ("one the all"); and the planetary symbols share the space inside concentric circles with the maxim in Greek: "One is all, and through it is all, and by it is all, and if you have not all, all is nothing". The distillation apparatus appears.

The process of transmutation was effected by a powder called *xerion* (ξηρίον), the contemporary meaning being a cosmetic or dusting powder. The name became the Arabic *al iksir*, or *elixir*, another name for the Philosophers' Stone. The transmuting process was also likened to dyeing, or a tinctorial process, and the Philosophers' Stone was called the *tincture*.

The most copious Greek alchemical author is Zosimos of Panopolis, A.D. 250–300, of whom a commentator admiringly says: "His words are as abundant as the ocean". His twenty-eight treatises were addressed to his 'sister' Theosebeia, a lady of rank, "clothed in the purple", and probably a member, or 'sister', of a small study-circle. Zosimos classifies things into *bodies* (metals), and *spirits* (πνεύματα), "certain substances which are by reason of their nature invisible", namely, the vapours of mercury, arsenic, and sulphur, which he also calls 'vapours' or 'smokes', as do later Arabic authors. He came near the recognition of gases. His works contain some remarkable visions which have engaged the attention of the psychoanalysts.

Besides the Demokritan school, there are traces of others: Zosimos sends his malicious regards to a priest Neilos, and his 'sister' Paphnutia, who wasted a day in roasting a mineral in a common kitchen fireplace instead of in a *kerotakis*, and got nothing but a heap of ashes. They had omitted the bell-jar to receive the sublimate.

After Zosimos, the treatises are mostly commentaries. The last author is Stephanos, a court professor at Constantinople, whose works are largely rhetorical.

The Saracen conquests of the seventh century A.D. shifted the stage of alchemy to Syria and Mesopotamia, where it was known as *al kimiya*, the old name being retained. The Greek works of Demokritos and Zosimos appeared in Syriac translation, some of which are extant.

Saracen alchemy is mainly linked with the names of Jābir ibn Hāyyan, known in the West as Geber, about A.D. 750; al-Rāzī, known in Europe as Rhases, a Persian physician, A.D. 866–925; and the physician ibn Sina, or Avicenna, A.D. 980–1036. The Latin works attributed to Geber, which long passed as a translation from Jābir, belong to a later date, and even the authenticity of the quite different Arabic works of Jābir has been called in question.

An Arabic work on alchemy, the "Secret of Secrets", attributed to al-Rāzī, has been translated by Ruska. An important Latin work on alchemy, the "de Anima", attributed to Avicenna, was known to Roger Bacon. It seems to have been compiled in Spain from Arabic sources about A.D. 1140. Avicenna was really a critic of alchemy. In a genuine work, the "Book of the Remedy", he says it is not in the power of the alchemists to bring about any true change of metallic species. They can produce imitations so as to deceive even the most expert, yet in these the essential nature remains unchanged.

This criticism was often added to the fourth book of Aristotle's "Meteorology" in Latin translations from Arabic, and was often attributed to Aristotle himself. The passage attracted the attention of the Schoolmen of the thirteenth century, and alchemy became a subject of interest to them.

Albertus Magnus (1193–1280) gives a good summary of alchemy in his "de Mineralibus", in which he mentions the frauds of Paris alchemists. He says alchemical gold, although it stood six or seven ignitions in the fire, was at last turned into dust. Albert, like Roger Bacon, believed in the possibility of alchemy on philosophical grounds; but the treatise on alchemy called "Semita Recta", or the "Straight Path", attributed to him and printed in his works, is spurious.

Roger Bacon (1214–92) divided alchemy into: (i) theoretical or speculative, which treats of the generation of things from elements, and of all kinds of metals, minerals, etc., of which Aristotle and the Latin authors were ignorant; and (ii) practical or operative, which teaches how to make gold and other things better by art than in Nature, and also powerful medicines by sublimation, distillation, etc. Bacon, and also Arnald of Villanova (1240–1311), emphasized the importance of chemistry in medicine long before Paracelsus. Ramon Lull, or Raymund Lully (1233–1316), attacks fraudulent alchemy in his works; a large alchemical literature attributed to him perhaps originated in his school soon after his death. St. Thomas Aquinas, who also had spurious alchemical works attributed to him, discusses in his genuine works the propriety of proffering alchemical gold in payment of debts, concluding that it is lawful if the artificial gold will pass the tests of the goldsmith.

Although the Schoolmen soon lost interest in alchemy, which most of them regarded as fraudulent, the less learned were much attracted by it, and great numbers of people began to study it practically. The paintings of the Dutch schools, especially, show the alchemists at work. Numerous works on alchemy appeared in the fourteenth and fifteenth centuries. Many of these works treat of the supposed mystical aspects of alchemy, a branch which seems to have owed much to Jewish sources, with their preoccupation with anthropocentric diagrams, and the mysteries of the macrocosm and the microcosm.

The "Mirror of Alchemy", wrongly attributed to Roger Bacon but probably almost contemporary, says: "Alchemy is a science which teaches how to make a certain medicine called elixir, the which when it is cast upon metals or imperfect bodies fully perfects them by mere projection. . . . The natural principles of mines are mercury and sulphur. All metals and minerals, of which there are many kinds, are begotten of these two; . . . Nature always intends and strives to the perfection of gold, but many accidents coming between change the metals. . . . For according to the purity or impurity of the two aforesaid principles, mercury and sulphur, pure and impure metals are engendered."

This theory appears in the Saracen authors, and has been attributed to Jābir. It is almost implied in, and seems to be based on, a passage in Aristotle's "Meteorology", in which the formation of metals from two vapours in the earth is expounded.

The alchemists, with their green dragons, red lions, black crows, roses, lilies, and salamanders, feature in literature as well as in art. Chaucer (1345–1400) and Ben Jonson (1572–1637) have much to say about them. English alchemical writings were Thomas Norton's "Ordinal of Alchemy", in verse, supposed to have been written in 1477, and Ripley's works in verse. These are included in Ashmole's "Theatrum Chemicum Britannicum" (1652). Davy correctly says of Ripley's poems that "there is nothing in them which can instruct or amuse an intelligent reader".

Although some alchemists were charlatans, others were sincere, and by experiments, although they never made gold, discovered many useful things like the mineral acids, and pointed the way to a richer knowledge.

Alchemy also flourished at an early date in China, the most celebrated Chinese alchemist being Ko Hung, in the fourth century A.D. Distillation was known, and the Philosophers' Stone, called the *tan*, was supposed to be the elixir of life. Great interest was taken in the synthesis of red cinnabar from mercury and sulphur. Alchemy was also studied in India, where the atomic theory was taught at a fairly early date.

Although Roger Bacon and Arnald of Villanova in the thirteenth century had emphasized the use of chemistry in medicine, this first became important with Paracelsus, born in 1493 at Einsiedeln in Switzerland. After a wandering life, in which he acquired information on alchemy and medicine, he occupied the chair of medicine at Basle for the single session 1527–28. Thereafter he led an unsettled life, dying at Salzburg in 1541. He was a reformer of medicine, and his contributions to chemistry are slight. He believed in the four elements, but thought they appeared as the three principles, or *tria prima*, of salt, sulphur, and mercury, the first being added by him to the two alchemical principles to denote the principle of fixity and incombustibility. Paracelsus gave the name 'alcohol' to spirit of wine.

Van Helmont (1577–1644), of Brussels, whose writings were published by his son in 1648, adopted some views of Paracelsus, but criticized others. He believed that water is the fundamental element, and tried to prove this by growing a tree from a weight of 5 lb. to 200 lb., supplying it only with water. He overlooked the carbon dioxide in the atmosphere, although he was the first to recognize this, calling it *gas sylvestre*, and inventing the name 'gas', which he says he derived from 'chaos'. He thought a gas could not be kept in a vessel, for he corked up limestone and acid in a bottle, which soon burst. Van Helmont mentions nitric oxide gas from metals and nitric acid, and an inflammable gas which he calls *gas pingue*. He made quantitative experiments, and showed that when a metal is dissolved in an acid it can be recovered again with its original weight from the solution. He recognized that digestion is effected by some kind of ferment in the stomach. Van Helmont believed in a universal solvent, called *alkahest*, but does not explain how he was able to keep it. Boyle had a high opinion of van Helmont, who, in spite of some credulity, was a highly original thinker and a clever experimenter.

Chemistry proper appears about his time, and its first text-book is the "Alchemia" of Libavius (1597), which included the teachings of Paracelsus, but criticized his absurdities. It is a well-arranged work. Libavius describes zinc, and discovered anhydrous stannic chloride, afterwards known as "Libavius's fuming liquor".

Glauber (1604–70), another German, was a skilled practical chemist. In his book, "New Philosophical Furnaces" (1646–49), he describes the preparation of spirit of salt (hydrochloric acid), and by dissolving metals in it he prepared many new salts, the metal chlorides. Sodium sulphate is still known as 'Glauber's salt'. He made malt extract, and another of his experiments is the 'chemical garden', made by putting bits of metallic salts in a solution of water glass.

A popular text-book was the "Cours de Chymie" of a Frenchman, Lemery, first published in 1675, which went through a large number of editions and translations. It divides bodies into animal, vegetable, and mineral, and uses the corpuscular theory, explaining properties by the different forms of the particles, acids having sharp-pointed particles which prick the tongue, and tear apart and dissolve metals.

Tachenius, a German who worked for a time in a soap factory in Venice, in his "Hippocrates Chimicus" (1666) defines a salt as composed of an acid and a base. Kunckel, an alchemist in the service of Frederick William of Brandenburg, the Grosse Kürfürst, in Berlin, independently discovered phosphorus and gold ruby glass. His "Laboratorium Chymicum" was published in 1716, after his death in 1703. He admits that he failed to transmute metals into gold.

Chemistry assumed a new dignity, and became scientific, by the work of Robert Boyle (1627–91), who insisted that it was worthy of independent study, and was not merely the handmaid of alchemy or medicine. In his "Sceptical Chymist" (1661) he shows that the true elements are not the four elements, or the three alchemical principles, since none of these can be extracted from bodies. He believed in the atomic (or as he calls it, the corpuscular) theory, and suggested that different bodies result from the different motions and mutual actions of the

small particles of matter. The famous Boyle's law was stated in 1662, and many experiments were made with an air pump, with which it was shown that combustion would not proceed in a vacuum, unless the combustible were mixed with nitre or saltpetre, which led him to suspect that this salt contains something also present in the air. This theory was elaborated by Hooke and Mayow, both of whom worked with Boyle in Oxford.

John Mayow (1641–79), born in Cornwall, was later a physician in Bath and London. His "Tractatus Quinque" (1674) describes fundamental experiments on combustion and respiration, both of which he says are maintained by a part of the atmosphere present in a fixed state in nitre, and which he called the 'nitro-aerial spirit'. He showed that antimony gains in weight when calcined in air, and supposed that this is due to absorption of nitro-aerial spirit. The increase in weight of tin and lead on calcination in air had been described by a French physician, Jean Rey, in 1630, who suggested, not very clearly, that air is fixed in the process.

The study of combustion and calcination by Boyle and Mayow, if pursued, would have led to a correct theory, but it was interrupted by the appearance of a theory which long retarded the progress of chemistry. This was the famous phlogiston theory of Becher and Stahl.

Becher, born in 1635 at Speyer in Germany, was for a time in England, where he is said, on not very good authority, to have died in 1682. In his book "Physicæ Subterraneæ" (1669), he gives as constituents of bodies, air, water, and three earths, one of which is inflammable (*terra pinguis*), the second mercurial, and the third fusible or vitreous. These earths correspond with sulphur, mercury, and salt.

Stahl, born in Anspach in 1660, studied medicine at Jena, where he lectured on chemistry; he became in 1694 professor of medicine at Halle, but left in 1716 to become physician to the King of Prussia in Berlin, where he died in 1734. His first statement of the phlogiston theory was in his "Zymotechnia Fundamentalis" (1697). It was extended in his edition of Becher's "Physica Subterranea" in 1703, and in his "Fundamenta Chymiæ" (two editions in 1723 and 1746–47). All combustible bodies and metals were supposed to contain a common and identical principle, to which Stahl gave the name *phlogiston*. This was similar to Becher's *terra pinguis*, and could be transferred from one body to another. A metal on calcination loses phlogiston and becomes a calx (an oxide), which when heated with oil or charcoal takes up phlogiston again and reverts to metal. A metal is thus regarded as a compound of its calx (an element) and phlogiston. The known fact that the calx weighs more than the metal was a difficulty, explained (when it was thought worthy of consideration at all!) in various unsatisfactory ways, one being that phlogiston had a negative weight. The phlogiston theory was generally accepted during the eighteenth century, but Boerhaave, professor at Leyden, does not mention it in his famous text-book, "Elementa Chemiæ" (1732), each genuine copy of which is signed by the author.

It was only after the discovery of oxygen that a correct theory of combustion could be formulated. Oxygen was discovered independently by Scheele in Sweden about 1772 and by Priestley in England in 1774, but both continued to believe in the phlogiston theory. The correct explanation of their experiments was first given by Lavoisier.

Between the enunciation of the phlogiston theory by Stahl, and its overthrow by Lavoisier, many distinguished chemists had made important discoveries: Black, Priestley, and Cavendish in Britain; Bergman and Scheele in Sweden; Macquer and Baumé in France; and Marggraf (the discoverer of beet sugar) in Germany. Cavendish and Priestley made great progress in the discovery of gases, the latter using the familiar pneumatic trough for collecting them in jars over water. Soluble gases were collected over mercury.

Lavoisier overthrew the phlogiston theory, and put the new theory in its place, largely by the use of the balance, and the earlier work of Black was also founded on quantitative experiments; Lavoisier, although not always giving enough credit to his predecessors, emphasized the importance of Black's work, which he says he took as a model for his own.

Joseph Black, born in 1728, in Bordeaux (where his parents had emigrated to set up a wine business), studied medicine and chemistry in the University of Glasgow, where in 1756 he succeeded Cullen as professor of chemistry. In 1754 he became M.D. of Edinburgh with a dissertation on magnesia, published in an enlarged form in 1756. In 1766 he succeeded Cullen at Edinburgh as professor of chemistry, where he remained until his death in 1799. Black's lectures attracted large audiences and were illustrated by excellent experiments. The lectures were published in two volumes in 1803 by his pupil Robison, and were also translated into German. Before this, many manuscript copies were in circulation, and several still survive. One copy, interesting on account of its early date (1767–68), was made by Thomas Cochrane, and is illustrated by some clever drawings of Black.

In Black's time, two fixed alkalis, potash and soda, and a volatile alkali, ammonia, were known both in so-called mild forms, and in the caustic forms obtained from these by boiling with water and slaked lime, made from quicklime and water. The quicklime was changed into limestone or chalk, and the alkali became caustic. The phlogistic chemists explained this as due to the passage of a fiery or caustic principle (which the limestone had taken up on burning) from the quicklime into the mild alkali, which became caustic. Thus, quicklime was a compound of limestone and the fiery principle (called *acidum pingue* by Meyer), and caustic alkali a compound of mild alkali and acidum pingue. Black showed that limestone when burnt to quicklime, and a mild alkali when it becomes caustic, both lose weight. On burning limestone, a gas escapes. This is what Van Helmont called *gas sylvestre*; Black called it 'fixed air'; it is carbon dioxide. Limestone is thus a compound of quicklime and fixed air, and mild alkali a compound of caustic alkali and fixed air. On boiling mild alkali with quicklime, the latter takes fixed air from the alkali, leaving it caustic, and is itself converted into limestone. All this Black proved by exact weighings. Black knew that fixed air is evolved from the lungs on expiration.

Scheele and Priestley obtained oxygen in several ways, notably by heating red oxide of mercury, or red precipitate. They found it to support combustion much better than common air; and Scheele that the whole of the oxygen gas is used up in the process, whereas common air left four-fifths of its volume of a gas which did not support combustion or respiration.

Antoine Lavoisier, born in France in 1734, was carefully educated and, having ample means, devoted himself to science. His most important work was begun in 1770, and continued until his death on the guillotine in 1794, when he suffered the penalty of a *Fermier général*, or tax collector, although he had discharged this office honourably and honestly, as well as doing much important work in the service of the State.

Lavoisier learned of the isolation of oxygen in 1774 from Priestley himself in Paris, and soon saw that it was a part of the air concerned with combustion and calcination, which resulted from a combination of oxygen with the combustible or metal, and not from a loss of phlogiston. In the course of further work, he confirmed this conclusion, which he stated fully in 1783.

Since non-metals such as sulphur, phosphorus and carbon, on combustion in oxygen, form acids, Lavoisier proposed the name *principe oxigine*, from the Greek meaning 'producer of acids'. He drew up a list of elements, these being substances which, so far, had not been divided by chemical processes into any simpler bodies, and in 1789 he published his famous text-book, "Traité Élémentaire de Chimie". In this he describes an experiment in which mercury is heated in a confined volume of air, when it slowly takes up oxygen to form some red oxide, and the air contracts to a limiting volume. On heating the red oxide, oxygen is evolved, in volume equal to the contraction suffered by the air. Lavoisier also showed that oxygen is absorbed in the blood in respiration, as Mayow suspected, and carbon dioxide evolved, the oxidation of material containing carbon being the source of animal heat. With Lavoisier, chemistry entered its modern phase. Only one further step remained, and this was taken by John Dalton by the introduction of the atomic theory.

The atomic theory goes back to the old Greek philosopher Demokritos, about 450 B.C., was revived in the Epicurean philosophy, and made into a poem by Lucretius. It was never lost sight of, but was notably revived by Gassend early in the seventeenth century. Newton made extensive use of it, and an early application to chemistry was by William Higgins in 1789, who recognized that combination occurs in multiple proportions by successive addition of 1, 2, 3, etc., particles of one element, say oxygen, to one particle of another, say nitrogen. Higgins's work was appreciatively mentioned by Davy. Richter, in Germany, from 1791, had introduced the idea of combining weights.

John Dalton was born in 1766 in Cumberland, his parents being Quakers, to which society he himself belonged. His circumstances were modest, and he supported himself all his life by teaching, being appointed professor of mathematics and natural philosophy in New College, Manchester, in 1793. The College later moved to York, but Dalton remained in Manchester, earning his living as a private tutor, until his death in 1844. One of his pupils was the great physicist Joule. Dalton's main characteristics were plainness, modesty, and perseverance, united to genius.

Dalton's atomic theory arose from the influence of Newton, whose writings he had carefully studied. He took from Newton the theory that a gas exerts a pressure because of repulsive forces between its particles, the latter being at rest. The kinetic theory, postulating that pressure is due to bombardment by moving particles, although proposed by Bernoulli in 1738, had dropped out of sight. Dalton supposed that the repulsion was due to atmospheres of heat, which Lavoisier supposed was an imponderable material element called 'caloric', surrounding the material atoms.

In 1801–2, Dalton read several important papers to the Manchester Literary and Philosophical Society, describing the law of partial pressures, the solubilities of mixed gases, and the vapour pressures of liquids; and in 1803 he read a paper on "The Proportions of the Several Gases or Elastic Fluids Constituting the Atmosphere", to which, when it was first printed in 1805, the first table of atomic weights had, in the interval, been added. He was in possession of this theory before 1804, since in August of that year he explained it to Thomas Thomson, who published an account of it in 1807. The theory, and atomic symbols, are used in Dalton notebooks of 1803.

Dalton seems to have been led to the atomic theory on physical grounds in attempts to explain the properties of mixed gases. He calculated the relative weights of the atoms, taking the weight of the lightest atom, that of hydrogen, as 1. In order to do this, he made assumptions about the numbers of atoms combining; for example, he supposed that water contains one atom each of hydrogen and oxygen; whereas we now know that it contains two of hydrogen and one of oxygen. The theory explained the facts of chemical combination, including the law of multiple proportions, and the results found by Richter. Dalton's theory was first made known by Thomas Thomson, professor at Glasgow, who gave an account of it in his "System of Chemistry" in 1807. The first volume of Dalton's "New System of Chemical Philosophy" appeared in 1808. Dalton used curious symbols, that for hydrogen being ⊙, like the Bohr atom; the modern chemical symbols were introduced by Berzelius in 1813.

Dalton's atomic theory is the great guiding principle of modern chemistry. It has suffered slight modification, since all the atoms of a given element are not of identical weight, as Dalton thought; and also, as Newton suspected, it has proved possible to divide atoms experimentally into simpler parts, so that the atoms are formed of a small number of primary particles, and the artificial transmutation of elements is now a fact. If anything, however, the atoms have become more real than they were even for Dalton, who saw them clearly in the eye of the mind.

With Dalton, chemistry had become a modern science, and a history of alchemy and early chemistry ends; he brought the science to the beginning of the road it has followed ever since.

EARTH MOVEMENT RESULTING FROM AN ATOMIC BOMB EXPLOSION

IN 1904, Horace Lamb published[1] solutions of elastic wave equations, and predicted the wave pattern at a distant point from waves generated by an impulsive force applied vertically at the earth's surface. From this work he suggested that the general to-and-fro movement characteristic of a seismogram might be due either to a succession of primitive shocks or to instrumental imperfections.

On Monday, July 16, 1945, Lamb's conditions of a single initial vertical ground impulse were met

experimentally for the first time at the test of the atomic bomb in Jornada del Muerto Valley, New Mexico. On that occasion the source of the earth tremors was a simple single instantaneous vertical impact on the ground produced by the explosion of an atomic bomb 100 ft. above the surface. There was no succession of primitive shocks to explain unpredicted oscillations, and the three-component Leet seismograph orientated in three mutually perpendicular directions, (*a*) horizontally from point of observation to point of explosion, (*b*) horizontally at right angles to (*a*), and (*c*) vertical, was magnetically damped about 0·7 critical, so there was no question of instrumental self-oscillation. The magnitude of the ground vibrations has not yet been made public, but the qualitative analysis of the records has just been published by L. Don Leet[2].

The seismograms showed continuous oscillation. The first waves to arrive were P_2, refracted compressional waves, on the longitudinal and vertical seismograms, followed by S_2, refracted shear waves, on the transverse seismogram. After these came the P_1, direct compressional waves on the longitudinal and vertical components. Coupled waves on all components succeeded these, and were followed by *H*, hydrodynamic waves, on the longitudinal and vertical components. Surface shear waves arrived at the point of observation shortly afterwards and were recorded on the transverse seismogram. The latter ones of these were accompanied by horizontally polarized surface compressional waves on the longitudinal seismogram. The remaining part of the seismograms had Rayleigh waves on the longitudinal and vertical components and surface shear waves on the transverse seismogram.

P_2 was the standard bodily compressional wave. Leet states that from its angle of emergence as well as its velocity, the wave must have been refracted through material capable of transmitting waves of higher velocity than the surface layer could. P_1 travelled through the earth's surface layer. S_2 was an independent transverse wave assumed to have been a refracted body wave because of its velocity and period. Leet noted transverse motion from the very beginning of the record. *C* has been called the coupled wave. It was not predicted by standard elasticity theory, but was observed by Leet in 1939[3]. The diagnostic characteristic of this wave is that a particle in its path moves along the diagonal of a rectangular frame facing in the longitudinal direction. This results in simultaneous maxima and minima on all three components of the seismograph registrations. A novel feature of this wave on the atomic bomb record was that it was twinned. There was a *C* wave of period 0·4 sec. arriving at the same time and co-existing with one of period about 1·0 sec. The motion of a particle was left up push – right down pull. *Q*, the surface shear wave, arrived on the transverse component just as *C* was dying out. *H*, the hydrodynamic wave, was new to seismology. The wave caused a particle in its path to move in a longitudinal–vertical plane, clearly independent of motion on the transverse component at the same time. Leet states that the unique and significant thing about the *H* motion is that it is the opposite of that of the Rayleigh wave, and the particle at the top of its inclined elliptical orbit moves forward as for a wave on water. He is of the opinion that it seems reasonable to attribute the existence of the *H* wave to special properties of the material at the surface of the Jornada del Muerto Valley, namely, alluvial sands and gravels. A similar wave has been observed by Leet from a small dynamite shot in an area having a surface layer of sand 55 ft. thick underlain by clay 165 ft. thick. In both cases the horizontal component of *H* dominated the vertical, and the major axis of the elliptical path was inclined at an acute angle to the horizontal plane. *R*, the Rayleigh wave, caused particle movement in an elliptic orbit with the minor axis longitudinal and the major axis vertical. At the top of its elliptical orbit, the particle moved towards the source. The vertical component was larger relative to the horizontal than for *H*, but not in the classical ratio of vertical : horizontal = 1·5 : 1. The coupled wave carried an appreciable portion of the energy in the ground waves, and the hydrodynamic wave produced the greatest displacements on the record.

Leet's paper represents an important advance towards the solution of the seismological problem of establishing observationally the types of waves which can be supported by earth materials in their natural position.

[1] *Phil. Trans. Roy. Soc.*, A, **203**, 1 (1904).
[2] Leet, L. Don, "Earth Motion from the Atomic Bomb Test", *American Scientist*, **34**, No. 2 (1946).
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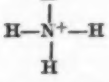
RELATIONSHIP BETWEEN STRUCTURE AND ACTION IN DRUGS WITH CURARIFORM ACTIONS

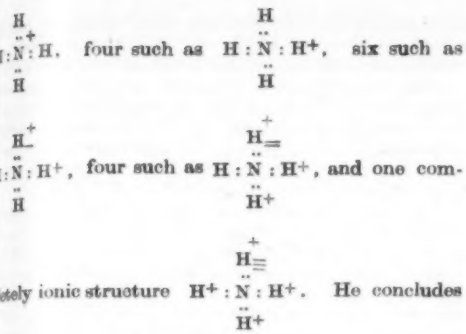
By P. E. B. HOLMES, D. J. JENDEN
AND
DR. D. B. TAYLOR
Departments of Physiology and Pharmacology, King's College, London

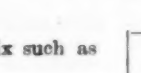
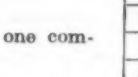
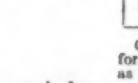
ING and Wright[1,2], in two comprehensive papers, presented the results of the measurement of the curariform activity of an extensive series of onium salts. Later, Ing[3] reviewed the literature up to 1936. Since that time much interesting work on the subject has appeared, the three papers by Raventos[4], Clark and Raventos[5] and Raventos[6] being of special interest from the theoretical point of view.

We can start with a consideration of the differences between the structure of the ammonium ion according to the classical theory of valency and the structure of the same ion according to quantum mechanics. Classical theory assigned the structure



to the ammonium ion, and tacitly assumed the charge to be localized to the nitrogen atom. The development of quantum mechanics has, however, led to a reconsideration of this structure, and Pauling[7] has pointed out that resonance between ionic and covalent bonds of the type $A—B \rightleftharpoons A^+ B^-$ will result in a distribution of the positive charge in the ammonium ion. He points out that sixteen structures have to be considered, one completely covalent structure



four such as  , six such as , four such as  , and one completely ionic structure  . He concludes that the unit ionic charge is distributed approximately equally among the five atoms, the nitrogen atom, therefore, being left with only + 0·2 charge.

Further, according to Pauling's view, the ionic contribution to the bond $[R_3X-R]^+$ in an onium ion (and hence the charge-distributing effect) will depend on the relative electro-negativity of the group R and the atom X and, other things being equal, on the ionic radius of both R and X. From these considerations alone it is difficult to avoid the conclusion that curariform action, a property of onium ions in a very widely different series of compounds, will be effected by the intra-ionic positive charge distribution. In attempting to apply these ideas, we will consider the compounds of the ammonium series first and then inquire into the effect of replacing the nitrogen atom by sulphur, phosphorus and arsenic, and finally try to assess the influence of complex molecular structure on the distribution of the central positive charge.

We can attempt to determine the influence of the group R in $[R_4N]^+$ in two different ways. First, a comparison of the dissociation constants of acids of the series RCOOH should give us an indication of the order of relative electro-negativity of R. In comparing the series RCOOH and $[R_4N]^+$, it is clear that the relative effects of the series on the charge on the nitrogen atom will be magnified because four R groups act on it as compared with one in RCOOH. Secondly, consideration of the dissociation constants of the corresponding primary, secondary and tertiary amines should be of interest. Here the dissociation constants are a measure of the reactions

$$[RH_2N—H]^+ \rightleftharpoons RH_2N + H^+$$
$$[R_2HN—H]^+ \rightleftharpoons R_2HN + H^+$$
$$[R_3N—H]^+ \rightleftharpoons R_3N + H^+$$

and hence their magnitude will be influenced by the charge on the central nitrogen atom.

TABLE 1

Group R	Curariform activity of R_4NI	$K_A \times 10^5$ of R—COOH	$K_B \times 10^5$ of $R_3NH(OH)$	$K_B \times 10^5$ of $R_2NH_2(OH)$	$K_B \times 10^5$ of $RNH_3(OH)$
CH_3^-	5·8	1·753	5·45	52	43·8
$C_2H_5^-$	No action	1·338	64	126	56
$C_3H_7^-$	11·5	1·542	55	102	47
$C_4H_9^-$	6·25	1·380			

Curariform activity[1] is expressed in minutes required to paralyse frog sartorius.

TABLE 2

Onium ion	Curariform activity of onium ion	Corresponding single bond with H	Dipole moment $\times 10^{18}$ of bonds in previous column
$[(CH_3)_4N]^+$	5·8	N—H	1·31
$[(CH_3)_3S]^+$	16	S—H	0·68
$[(CH_3)_4P]^+$	17	P—H	0·36
$[(CH_3)_4As]^+$	No action	H—As	0·10

Curariform activity is expressed as in Table 1. The dipole moment for As—H is in the opposite direction to the others, hence it is shown as H—As. The dipole moment values are from Pauling[2].

These lines of approach are limited by the lack of reliable values for the dissociation constants required.

In each series in Table 1 we see that when R is $C_2H_5^-$ the bases are strongest and the acid weakest. This anomaly is also seen in much more marked form in the curariform activity column. If we assume that the $C_2H_5^-$ group is not so electron-attracting as the rest, we can conclude that when the positive charge on the nitrogen atom in simple onium salts falls below a certain level, the compound loses its pharmacological activity very rapidly.

In the case of the symmetrical onium ions derived from nitrogen, sulphur, phosphorus and arsenic, we can obtain a qualitative idea of the influence of the central atom on the partial ionic character of the X—CH_3 bond from the dipole moments of the corresponding X—H bonds, because change in X from nitrogen to sulphur to phosphorus to arsenic should influence both CH_3^- and H^- bonds in the same sense. But since the central charge on the onium atom depends on the amount of partial ionic character in the X—CH_3 bond, the central charge should vary with the dipole moment in the correct direction. That it does (Table 2) is clear except in the case of arsenic, where there is a sudden loss in curariform activity. This sudden failure is like that which occurs in $[(C_2H_5)_4N]^+$. In N—H and S—H the relative electro-negativity of the atoms in the bonds is such as to move the electrons towards the hydrogen atoms, nitrogen having more effect than sulphur, and hence to increase the positive charge on the central atom. In P—H the relative electro-negativity is zero, and in As—H it acts to decrease the charge on the central atom.

It seems clear, therefore, that in any onium ion of the type $[R_n—X]^+$ the charge distribution in the ion and hence that left on X will depend on the relative electro-negativity of R and X; and it appears that curariform activity requires that the central positive charge should not fall below a certain level.

It has been known to chemists for a long time that conjugated systems have a charge-distributing effect. We would therefore expect, other things being equal, to find less curariform activity from onium atoms attached to unsaturated systems, as opposed to the corresponding saturated compound. In this connexion it is noteworthy that at a concentration of 2 millimols per litre (Ing and Wright[3]) both dimethyltetrahydroquinolinium iodide and methyl ethyltetrahydroquinolinium iodide are more active than the corresponding unsaturated compounds methyl quinolinium iodide and ethyl quinolinium iodide.

The above theory as it stands does not explain why, when nitrogen forms part of a ring system, replacement of methyl by ethyl in the quaternary

salt leads to an increase in curariform action if the ring is aromatic and to a decrease if the ring be saturated. It is possible, however, that the quasi triple bond $H_3{\equiv}C-$ in methyl may hyperconjugate[8] if the ring be aromatic; this would cause an electron shift towards the ring and hence a decrease in the charge on the N atom which could not occur to such an extent if $C_2H_5^-$ were present instead of CH_3^-.

This theory does not explain why tetraethyl arsonium is more active than tetramethyl arsonium; but as Malone[9] has pointed out, the relationship between relative electro-negativity and bond dipole moment between arsenic and several other atoms is anomalous; and in the absence of further physico-chemical information on the bond in the trimethyl and triethyl arsonium iodides, it is difficult to see how these considerations can connect the physical and pharmacological anomalies in these two compounds.

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[2] Ing, H. R., and Wright, W. M., *Proc. Roy. Soc.*, B, **114**, 48 (1934).
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[4] Raventos, J., *Quart. J. Exp. Physiol.*, **26**, 361 (1936–37).
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[8] Mulliken, R. S., Rieke, C. A., and Brown, W. G., *J. Amer. Chem. Soc.*, **63**, 41 (1941).
[9] Malone, J. G., *J. Chem. Phys.*, **1**, 197 (1933).

SCIENTIFIC EXPEDITION TO THE ANTARCTIC WHALING GROUNDS, 1946–47

By Dr. R. A. M. CASE

A BRITISH scientific expedition is on its way to the Antarctic whaling grounds on board the new whale-factory ship *Balaena*, which has been equipped with a laboratory for biochemical and physiological work with specially designed apparatus for use at sea. The expedition has been organised by the Department of Scientific and Industrial Research on the initiative of Dr. Franklin Kidd, superintendent of the Low Temperature Research Station, Cambridge. It has as its main aim a study of the fuller utilization of the large potential supplies of whale meat protein for human food in view of the present world shortage of high-grade protein. Its secondary aim is the general one of advancing knowledge of the physiology and biochemistry of the whale. The expedition has been made possible by the collaboration of Messrs. United Whalers Ltd., who generously provided a laboratory and facilities for the investigations on board their new ship.

A preliminary investigation in 1939–40 by the Department under the leadership of Lieut.-Commander Marr of "Discovery" Investigations confirmed in the first place what whaling personnel have always stated, namely, that a large proportion of meat from the carcase is scarcely distinguishable from beef, and in the second place showed that there are wide variations in the quality of the meat from different carcases and from different parts of the same carcase. The meat shows a great diversity of colour, ranging from a pale veal tint through many shades of red to a curious deep red black, and this may possibly be correlated with the age of the whale[1].

The lean meat from the back muscles alone, the longissimus dorsi and psoas, on the basis of the total British and Norwegian pre-war catches, was estimated to amount to more than half a million tons, which is equivalent to about half the total amount of meat imported into Great Britain before the War.

The expedition will carry out palatability tests on a large number of whales and make observations on various factors which may have an influence on quality, such as: mode of death; whether accompanied by exhaustion; with or without bleeding; the time between slaughter and cutting up; and the subsequent freezing and storage history. Biochemical analyses will be carried out on board the whaling vessel on selected representative samples, and control samples frozen at various temperatures will be brought back for re-assessment and more complete analyses at the Low Temperature Research Station.

The above data, it is hoped, will be correlated with the biological data on the whole catch of the factory ship, collected by an inspector of the Ministry of Agriculture and Fisheries and by a biologist working for the "Discovery" Committee.

The diversity of colour will be studied, attention being paid to various fractions of the muscle pigment such as myoglobin, hæmoglobin and a third yellow protein fluorescing in ultra-violet light which has not yet been fully investigated, but which I have recently found in considerable quantities in frozen whale muscle by extraction with $M/15$ phosphate buffer at a pH of 6·5.

The opportunity will be taken to study the physiology and especially the under-water physiology of the whale and of collecting specimens of interest in other branches of science. The physiological work has the support of the Royal Naval Physiological Laboratory and the Royal Naval Personnel Research Committee. The interest of the former has led to the loan to the expedition of special equipment, such as, for example, recording thermographs of the harpoon type, for obtaining carcase temperatures, which will be of great value in collecting data required in fulfilment of the main objective. An attempt to obtain samples of blood and tissues from the whale carcase after it surfaces from its final dive will be made by a scientific man working in a self-contained oxygen swim-suit ('frog man suit'). In this way it is hoped to obtain some information about the gaseous equilibrium of a recently surfaced beast. A proper understanding of the diving mechanisms of whales might be used to throw more light on some problems of human divers. Members of the team underwent special training at Fort Blockhouse to enable them to carry out this project, and the Royal Navy has placed diving-gear at their disposal.

The under-water physiology of the whale is by no means unconnected with the qualities of whale meat as a food, because the character or composition of the muscles of the whale are adapted in several striking respects to the requirements of its submarine existence. There are indications from work carried out on material from the previous expedition that, as an indirect consequence of this adaptation, the proteins of whale meat are of exceptional value for growth by comparison with the meat proteins of land animals.

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NEWS and VIEWS

Mathematics at Sheffield: Prof. A. G. Walker

DR. ARTHUR GEOFFREY WALKER has been appointed to the chair of mathematics in the University of Sheffield, in succession to the late Prof. P. J. Daniell. Dr. Walker has been a member of the Department of Pure Mathematics at Liverpool for the past ten years. He is thirty-seven years old and was educated at Watford Grammar School and at Balliol College, Oxford. On taking his degree in 1931, he went to Edinburgh and commenced research under Prof. (now Sir) Edmund Whittaker. This was a time of exceptional activity at Edinburgh. Prof. Whittaker was mainly interested in relativity and differential geometry, and his staff, which in the years 1927–32 included E. T. Copson, J. M. Whittaker, J. G. Semple, H. S. Ruse, W. H. McCrea and A. Oppenheim, all of whom have gone on to professorial chairs, for the most part followed his lead. To Walker, who had gained distinction in differential geometry in the Final Honours School at Oxford, the subject of Prof. Whittaker's lectures was particularly congenial, and he wrote several papers, the first of a long series on differential geometry, relativity and cosmology. In 1933 he returned to Oxford to take up a Harmsworth Research Scholarship at Merton College, to which he had been elected in the previous year. He worked with Prof. E. A. Milne on kinematical relativity, then at the beginning of its stimulating and controversial career. This subject has continued to engage Dr. Walker's attention ever since. He is a supporter of Milne's general point of view, but has developed a more general theory, which seems capable of accounting both for cosmological effects and for phenomena due to intense local gravitational fields such as that of the sun. Certain functional equations present themselves in this work, and he has investigated them from the point of view of pure mathematics in collaboration with his Liverpool colleagues F. W. Bradley, now professor of mathematics at the University of Alexandria, and Miss Joyce Batty.

Fuel Technology at Sheffield: Prof. R. J. Sarjant, O.B.E.

THE chair of fuel technology in the University of Sheffield has been vacant since the death of Prof. R. V. Wheeler in 1938, and the appointment of Dr. R. J. Sarjant to it assumes added importance in view of the national coal situation and the industrial area served by the University. Dr. Sarjant, who is chairman of the Yorkshire Section of the Institute of Fuel, has wide academic knowledge and industrial experience; trained under the late Prof. W. A. Bone at the Imperial College of Science and Technology, London, where he worked upon the constitution of coal, he was appointed in 1918 as fuel officer to the Research Department of Messrs. Hadfields, Ltd., there undertaking tasks pioneering in character. He published with Sir Robert Hadfield a number of papers on the uses of solid, liquid and gaseous fuels, gas producer practice, alloy steels for furnaces and chemical engineering, and gave the first course of lectures on furnace heating at the University of Sheffield in 1924. His later investigations dealt with: special aspects of the design of open-hearth, reheating and heat-treatment furnaces; refractories and moulding sands; and various metallurgical, physical and radiological fields. In 1937 he was appointed a local director of Messrs. Hadfields, Ltd., and head of its Research Department; and during the War he rendered valuable service on a number of committees, particularly the Fuel Efficiency Committee of the Ministry of Fuel and Power, being chairman of its Education Sub-Committee which produced a notable war-time publication, "The Efficient Use of Fuel". He was the author of "Furnace Heating" (1925), and the section on fuel economy in industrial furnaces in "Coal: Its Constitution and Uses" (1936) by Bone and Himus. An account of his most recent research in collaboration with Prof. D. R. Hartree on the variable heat flow in solids has now appeared in the *Philosophical Transactions of the Royal Society*. Prof. Sarjant's appointment at the University of Sheffield will be widely welcomed.

Bicentenary of Johann Elert Bode

JANUARY 19 is the bicentenary of the birth of Johann Elert Bode, who at one time was the foremost astronomer in Germany. The son of a schoolmaster at Hamburg, from boyhood Bode was given to astronomical calculations and observations, and at the age of twenty-one published an elementary treatise which became very popular. He next published an essay on the transit of Venus of 1769. In 1772 Frederick II of Prussia called him to Berlin and made him astronomer to the Academy of Sciences, and the remainder of his life was spent in the Prussian capital. He commenced in 1774 the periodical *Astronomische Jahrbücher*, and in 1778 re-stated the law of planetary distance known by his name, which, however, had been stated previously by Titius and Wolf. It was through Bode that the name Uranus was given to the planet discovered by his fellow-countryman Herschel. His "Uranographia", published in 1801, gave observations of 17,240 stars. He made no important discoveries of astronomical objects, but by his writings and activities did much to diffuse a knowledge of astronomy in a country where for a time scientific studies had languished through the disasters of war. Bode died in Berlin on November 23, 1826, aged seventy-nine.

Cave Art at Lascaux

THE discovery during the War of prehistoric paintings in the Lascaux Caves near Montignac in south-western France is of the highest interest. A large pine tree had blown down, and some French boys wandering with their dog in the vicinity found under its roots the entrance to a hitherto unknown cave. On the walls were innumerable paintings, many of them of large size, which were soon recognized as being palæolithic. Lascaux, though some distance from the well-known cave sites near Les Eyzies, is after all not so far away from them, and local folk knew by hearsay all about such places as Font de Gaume, Combarelles, etc. But the new paintings (there are also some engravings), while similar in style to some of the paintings at these other sites, are for the most part different. Indeed, the importance of the new discovery is that it vastly increases our knowledge of the earlier styles, of which elsewhere we have so far only known a little. The Lascaux pictures are mainly of Aurignacian age, antedating the wonderful polychromes found at Altamira in northern Spain and Font de Gaume in the Dordogne, and throw a new light on the evolution of this Phase I of the cave art which is now likely to become a great deal clearer. Many of the figures are very large and include drawings of bulls, horses, stags, bison and rhinoceros.

In one or two instances the animals are painted with their tongues out—reminding one of certain paintings of the eastern Spanish rock-shelter art, as also does the way in which some of the Lascaux animal horns are depicted. These two circumstances back up the contention that a part at any rate of the eastern Spanish art is palæolithic in date. Altamira is the site where the finest Magdalenian paintings have been preserved. Lascaux can claim the same title in respect to the earlier Aurignacian art.

The All-Russian Mineralogical Society

THE Russian Mineralogical Society is celebrating its hundred and thirtieth anniversary during January 19–25, 1947, in Leningrad. This anniversary is being specially marked, because it was not possible to celebrate appropriately either the centenary or the hundred and twenty-fifth anniversary, since these occurred in 1917 and 1942 respectively. The Society is the oldest mineralogical society in the world—the Mineralogical Society of Great Britain and Ireland was founded in 1876 and the Société Minéralogique de France in 1878. Before the founding of the Geological Committee in 1881 in Russia, the Mineralogical Society was almost the only institution conducting regular geological and mineralogical exploration in that country. It thus became a centre for the collection of information concerning discoveries in little-known Russian regions. Among its most active members have been such brilliant scientific men as N. I. Koksharov, E. E. Chernyshev, E. E. Fedorov and A. Karpinsky. The present chairman of the Council is Academician S. S. Smirnov.

The Society has substantially influenced the development of the science of mineralogy through its publications, which began in 1830; they were issued at irregular intervals under various titles until 1866, when publication commenced of the periodical *Notes of the All-Russian Mineralogical Society* (*Zapiski Vserossiiskogo Mineralogicheskogo Obshchestva*). This was the first specialized mineralogical journal in the world; the *Mineralogical Magazine* commenced publication in 1877, *Bulletin de la Société Minéralogique de France* in 1878 and the *American Mineralogist* in 1916. Later Russian publications were the Bulletins and the Memoirs of the Geological Committee published departmentally (1883) and the Transactions of the Geological and Mineralogical Museum of the Academy of Sciences (1906). The discoveries of Russian mineralogists embodied in the *Notes* form an essential contribution to the world science of mineralogy. They include such classic memoirs as those by N. I. Koksharov and V. P. Yeremeyev reporting the measurements of minerals, the announcement by A. Gadoin of the discovery of 32 classes of symmetry, E. Federov's work on the discovery of the 230 space groups and many other important papers. The chief tasks of the Society are the exploration of the mineral wealth and soils of the U.S.S.R.; the spreading of mineralogical, geological and palæontological information within the U.S.S.R.; the establishment of closer contact among Russian men of science working in these fields and facilitating their relations with scientific institutions abroad.

A Monument to Darwin in Uruguay

IN *Nature* of July 24, 1937, p. 138, it was recorded that Prof. Karl Walther, of Montevideo, had erected a stone on the Cerro de los Claveles to commemorate Darwin's visit to the locality in 1833. The project matured during the years of war, and Walther's original suggestion has now resulted in the erection of a monolith to the memory of Darwin on the summit of the Cerro. The Cerro was Darwin's 'farthest north' in Uruguay, to which he travelled on horseback from Montevideo. Nowadays it is easier to approach it by rail from Montevideo to Mercedes, the capital of the Department of Soriano, and thence by road to the Cerro 50 km. or more to the north-east on the high southern bank of the Río Negro at its confluence with the Arroyo Perico Flaco. The nearest village, formerly Saca Chispas, about 5 km. to the south of the Cerro, has been renamed Darwin in honour of the great master. It is a source of much gratification to note how, after more than a hundred years, Darwin's name and fame are still being honoured and acclaimed in Uruguay.

Zoological Society of London: Anatomical Research Fellowship

THE Council of the Zoological Society of London has decided to re-establish a research fellowship in order to encourage investigations on the comparative anatomy of the animals brought to its prosectorium. The appointment offers unrivalled opportunities for work in this subject, in view of the wealth of material available, amounting during the course of an average year to approximately a thousand mammals, birds, reptiles and amphibians. Some of these animals belong to species likely to become extinct in the near future, and it is most important that some record of their anatomy should be preserved for the benefit of posterity. Also, contrary to the impression sometimes found among professed zoologists that comparative anatomy is an exhausted subject, little is known of the internal structure of any but the commonest animals. The prosectorium of a large zoological gardens offers the only opportunity of helping to fill these gaps in our knowledge. Such investigations are all the more urgent, since the extensive comparative anatomy collection of the Museum of the Royal College of Surgeons, built up mainly by Sir William Flower and his successors, was destroyed during the air raids—probably the worst single scientific loss of the War. It is hoped that the appointment will attract a student to a branch of zoology which, although rather out of fashion in recent times, remains the framework on which its many activities ultimately depend. Further information concerning the fellowship can be obtained from the Secretary, Zoological Society of London, Regent's Park, London, N.W.8.

War Industries and Town Planning

Two articles, by A. Shenfield and Prof. P. Sargant Florence, reprinted from the *Review of Economic Studies* (1944–45), have a bearing on the siting and development of new towns. The first article, "Labour for the War Industries: the Experience of Coventry", points out that the really important effect of the War upon Coventry is to be seen, not in the physical injuries which the city suffered, but in the conversion of its industries to war purposes and in their expansion to that end. Analysing the character and growth of the population of the city, Mr. Shenfield and Prof. Sargant Florence direct attention to the very high proportion of the workers of Coventry who at the beginning of the War were without roots in the city. This proportion was greatly increased

by the enforced war-time expansion of its industries, and the existence of a highly abnormal proportion of such newcomers in the population is regarded as aggravating the problems of war-time production; first, because the outward as well as the inward mobility of the immigrant tends to be higher than that of other workers; and secondly, because with a population largely recruited by the attraction of high earnings and composed of those ready to snatch advantage from slack management, Coventry was likely to show higher costs than some other centres would have done.

In the second paper, "The Economics and Diseconomics of Industrial Concentration: the War-time Experience of Coventry", analysis of such factors as the cost of labour turnover, absenteeism, higher earnings, transport and housing leads to the conclusion that the localization since 1939 of war industries in Coventry on the scale required by the Government's plans, and the immigration they involved, was scarcely justified. The fundamental weakness of the Government's original plans was that it did not envisage the economic conditions of total war. The story of Coventry is the story of a war plan framed not merely in, but also to fit, the conditions of peace; and it is by no means certain that it leaves the city fit to meet the conditions of peace to-day. Before the War, Coventry possessed industries which were prosperous and expanding and which, in spite of the seasonal variations of the making of motor-cars, were fairly diversified. Presumably aircraft production will be cut down, and Coventry will depend mainly on the motor-car industry. Unless all the labour imported since 1939 emigrates, Coventry will require a larger motor-car industry than in 1939, since its other pre-war industries may not have been restored. Moreover, at the end of the War, Coventry was specializing more narrowly than before on trades liable to cyclical as well as seasonal fluctuation. Prof. Sargant Florence and Mr. Shenfield conclude that plans should be prepared to guard against abnormally high unemployment. Diversification with industries not liable to cyclical fluctuation and likely to meet post-war demands for durable goods is required, using as a basis the expansion and fostering of offshoots from the electrical, engineering, metal-working and textile industries, so that Coventry approximates in character to its more balanced neighbours, Birmingham and Leicester.

Chemotherapy

EVERYONE who is interested in chemotherapy should not fail to consult the *British Medical Bulletin*, No. 4, Vol. 4, 1946, the sub-title of which is "Background to Chemotherapy". Introduced by a sketch of the history of chemotherapy by Dr. E. M. Lourie, this issue of the bulletin contains an article on the steps leading to the therapeutic application of microbial antagonism by Sir Howard Florey, one on the analysis of antibacterial action by Dr. H. MacIlwain, and a valuable article on the nutrition of bacteria by Sir Paul Fildes. Dr. F. R. Selbie contributes an article on microbial resistance to chemotherapeutic drugs, Prof. L. P. Garrod deals with the principles and practice of local chemotherapy, and Prof. J. H. Gaddum writes on the principles of administration in chemotherapy. Dr. C. H. Andrewes and Dr. Harold King have written a valuable article on the chemotherapy of the rickettsial and virus diseases.

It is good to see that space is also given to the important chemotherapeutical work done in France, which is summarized in an article on the contribution of the Institut Pasteur, Paris, to recent advances in microbial and functional chemotherapy by four members of the staff of this famous institution, Jacques Tréfouël, Mme. Jacques Tréfouël, Daniel Bovet and Frédéric Nitti. An interesting article by Prof. F. G. Young, entitled "Claude Bernard and Scientific Adventure", pays a just tribute to the work of this great man. The book reviews and the guide to current medical literature continue to be a valuable feature of the bulletin. In this issue there is also a very interesting article on the making of a catalogue of medical films by Dr. Brian Stanford, who is in charge of the reference catalogue of all the films of medical interest in Great Britain, which is being maintained by the co-operation of the Scientific Film Association and the Royal Society of Medicine. Some notes on health education films and some of those produced at the Pasteur Institute are also given.

British Scientific Instrument Research Association

ONE of the first steps taken in the major scheme of expansion which the British Scientific Instrument Research Association is at present engaged in putting into effect was the creation of an Information Department to serve both members and staff. This Department, in April 1946, began the publication of a printed monthly bulletin, consisting of about twenty pages an issue, and containing Association notes, and abstracts of current, including patent, literature relating to scientific instruments. The bulletin, at first, was circulated only to members of the Association, to whom it is supplied free of charge, but, in order that it may be of the greatest possible use to makers and users of scientific instruments, the Council of the Association has now decided to make the bulletin available to non-members at an annual subscription of £2.

The October issue of the bulletin (vol. 1, No. 10) records that the work of transferring the Association's research laboratories from Russell Square, London, to new and much larger premises at Chislehurst, Kent, is making good progress, and it is expected that a substantial section of the chemical laboratories will have been removed by the end of November. The response to the request sent out to members for copies of their catalogues and other publications has been very good, and it is hoped to maintain an up-to-date collection of these in the Association's Library. The offices of the Association are at 26 Russell Square, London, W.C.1. The chairman is Dr. W. H. Eccles; the director of research and secretary, Mr. A. J. Philpot; and the information officer, to whom all communications relating to the bulletin and requests for loan of documents should be addressed, is Mr. C. W. Hanson.

Instrument Practice

WITH the outbreak of hostilities in 1939 a number of important Continental journals disappeared from the literature of instrument technology. Many of these are again becoming available in Great Britain; but there is no doubt that there is room for more published information in this large and varied field of scientific thought. The issue of the first number of a new English publication on instrumentation is, therefore, a matter of great interest. The name of this monthly journal is *Instrument Practice*, and its title page states that it hopes to cover the whole

field of instrument technology and instrumentation. Its editorial policy is stated as serving and unifying the interests of instrument makers, users and technologists. The journal is primarily concerned with commercial rather than laboratory instruments, and it also aims at the publicizing of British instruments abroad. It will, therefore, be acknowledged that the new journal has set itself an impressive and ambitious task. A considerable section of the first issue is given to an account of a recent conference in the United States, with commentaries on the papers so brief as to be of little value in many cases. Another section is devoted to reprints of papers read before the Society of Instrument Technology. It is here that the new journal may serve a most useful purpose, as the papers of the Society have not yet been regularly published in any one journal. Permanent features cover new patents, news of the industry, trade and technical publications, particulars of new companies and a diary of forthcoming events.

Claims for War-time Awards for Inventions

THE rules of procedure of the Royal Commission on Awards to Inventors were published in September 1946 (*Nature*, September 28, p. 443). About fifty claims arising from the use of inventions by the British and Allied Governments during the War have so far been referred to the Commission. They relate to a wide field of invention and include claims in respect of 'Mulberry', the flail tank, which was first used in North Africa for destroying enemy mines, plastic armour for use on ships, amphibious tanks, the Bailey bridge, the sticky bomb, and many others. Many of these cases raise complicated scientific and legal issues, and the preparation of a case for hearing takes a considerable time. It has, therefore, been necessary to postpone the first public hearing of the Commission; but it is hoped that a case will be ready in the middle of February or the beginning of March. A committee consisting of the chairman, Lord Justice Cohen, the deputy chairman, Mr. Kenneth Swan, and the secretary has been set up to deal with preliminary matters which may arise in a claim before it is ready for hearing before the full Commission.

Blood Group Reference Laboratory

SINCE the Galton Laboratory Serum Unit (Medical Research Council), formerly at Cambridge, closed in May last, Dr. R. R. Race, the former director, has moved to the Lister Institute, London, where he is in charge of the new Blood Group Research Unit of the Medical Research Council. Dr. A. E. Mourant, who formerly assisted Dr. Race, has become director of the new Blood Group Reference Laboratory of the Ministry of Health. This Laboratory, which is part of the Ministry of Health Blood Transfusion Service, is also at the Lister Institute, and will provide grouping serum and investigate clinical blood-group problems. The juxtaposition of these two laboratories will be of great mutual benefit and ensure the close association of the theoretical and practical sides of this subject. Hospitals and medical men requiring grouping serum should, in the first instance, apply to their local regional transfusion centre, through which grouping serum will be issued.

Astrology in the Hellenistic Age

THE study of astrology fascinated mankind for some two thousand years. The fundamental idea was the association of a god with each planet and the transfer of the god's character and mythology to the planet. As a result the planet itself was believed to exercise a direct influence on mankind. A crude form of astrology grew up in Mesopotamia in prehistoric times. But Martin P. Nilsson (*Medd. Lunds Astron. Observ.*, ii, No. 111; 1943) suggests that the great system of astrology properly so called was a product of the Hellenistic age. Though based on the false premise already mentioned, the study of the heavens was scientific, and was the result of the labours of a number of scientific observers in the Hellenistic world.

Announcements

THE Gold Medal for 1947 of the Royal Astronomical Society has been awarded to Prof. M. G. J. Minnaert, of Utrecht, for his outstanding contribution to solar physics in general and solar spectrophotometry in particular.

THE annual general meeting of the Royal Meteorological Society will be held on January 22 at 5 p.m., when Mr. G. Manley will deliver his presidential address on "The Geographer's Contribution to Meteorology". The Symons Medal will be presented to Prof. David Brunt, in recognition of his distinguished services to meteorological science.

PROF. P. C. SARBADHIKARY, professor of botany, University of Colombo (Ceylon), has been appointed Sir Rash Behari Ghosh professor of botany in the University of Calcutta in succession to Prof. S. P. Agharkar, who retired in May.

MR. RONALD EDE has been appointed agricultural attaché to the British Legation in Copenhagen. Mr. Ede, who is forty-one years of age, has been secretary of the University School of Agriculture at Cambridge since 1929. He was secretary of the Luxmoore Committee on Post-war Agricultural Education which reported in 1943.

MR. W. J. DRUMMOND, deputy chairman of the North-Western Divisional Coal Board, has been appointed honorary secretary of the British National Committee of the World Power Conference, in succession to the late Mr. C. Rodgers.

COLONEL L. W. HARRISON has retired from the staff of the Ministry of Health, to which he has been adviser on venereal diseases since 1919. Colonel Harrison has been associated with the control of venereal diseases in England and Wales for nearly half a century. In recognition of his work the American Social Hygiene Association awarded him the William Freeman Snow Medal for 1946. He is the author of a number of books and papers on venereal disease.

THE following have been elected officers for 1947 of the New York Academy of Sciences: *President*, Dr. Harden F. Taylor; *Vice-Presidents*, Dr. Robert B. Sosman, Dr. S. Stansfeld Sargent, Dr. Ross F. Nigrelli, Walter Dyk, Bernhard Haurwitz; *Recording Secretary*, Dr. George B. Pegram; *Corresponding Secretary*, Prof. Athelstan F. Spilhaus; *Treasurer*, Marvin D. Thorn; *Librarian*, Prof. Victor K. La Mer; *Editor*, Dr. Roy Waldo Miner; *Members of Council* (1947–49), William Brown Bell, Harry C. Charipper, Dr. Caryl P. Haskins; *Finance Committee*, Addison Webb (chairman), William Ottis Sweet, Dr. Charles N. Frey.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Multiple Disintegration Processes Produced by Cosmic Rays

Some months ago, in collaboration with D. L. Livesey and L. V. Chilton[1], we described experiments on the prototype of the new photographic emulsions for the detection of fast protons and other heavy particles, which are now being produced by Ilford, Ltd., in various types and which are referred to as 'Nuclear Research Emulsions'. Our experience with these plates strongly suggested that they would be very suitable for detecting the multiple disintegration phenomena produced by the fast neutrons, γ-rays and other radiations in the cosmic rays[2,3,4,5]. We therefore exposed plates for six weeks at the Pic du Midi, Hautes Pyrenées, at a height of 3,800 metres, and in this communication we wish to direct attention to the important conclusions which can be drawn from an examination of the experimental material thus obtained.

In addition to the numerous long isolated tracks, which show a grain spacing characteristic of fast protons of energy up to 30 MeV., we observe, in emulsions of type *C*2, 40 μ thick, an average of two multiple disintegration 'stars' per sq. cm. of the plate. Up to the present, we have found more than three hundred events of this type. To avoid confusion due to any radioactive contamination of the emulsion, we accept for detailed study only those 'stars' in which there are three or more components, at least one of which has a range greater than 10 cm. of standard air. From the total area of our exposed plates, we conclude that we shall find about three thousand stars in a complete examination. We believe that this material is sufficiently extensive to enable us to establish regularities in the modes of disintegration of the light and heavy elements under bombardment with primary radiations of great energy.

We cannot, within the scope of a single communication, discuss the many interesting and novel events we have observed; but, as an example of the quality of the experimental material, we show, in Figs. 1 and 2, mosaics of photomicrographs of two comparatively simple disintegrations. We chose to photograph these particular 'stars' because they were among the first which we observed and they were of such a type that the work of constructing the mosaics was not unduly arduous. At the points where the track of each of the particles, radiating from the disintegrating nucleus, reaches the edge of the photograph, we show the total range of the corresponding particle in the emulsion, and indicate whether it ends in the emulsion (*e*), passes out of the surface (*s*), or into the glass (*g*). In making prints of the photographs for reproduction, the joins of the mosaic have been obliterated. At no stage in the photography, however, has any 'retouching' been done.

Fig. 1 shows a multiple disintegration in which the most prominent track, *A*, has a grain spacing characteristic of an α-particle. It ends in the emulsion and, from its observed range of 505 μ, we can conclude that its initial energy, at the moment of its ejection from the parent nucleus, was 36 MeV.[6]. The thinner tracks *B*, *C*, *D*, *E*, *G* and *H* have a grain spacing similar to that of protons of familiar energies (~ 20 MeV.), and they all pass out of the emulsion, while *F*, which passes into the glass, is probably an α-particle. In addition, the tracks of at least two short, very heavily ionizing particles can be distinguished in the original photographs.

Fig. 2 shows a multiple disintegration in which the two long tracks (*Z*) and (*Y*) are produced by protons. *Z* has a range of 290 μ (energy, 6·8 MeV.) and ends in the emulsion, while *Y* passes out of the surface after traversing a distance of 400 μ. The other tracks all leave the emulsion, so that we cannot make a certain identification of their nature; but, if their energies are each less than 30 MeV., (*X*) and (*W*) are protons and (*V*) is an α-particle.

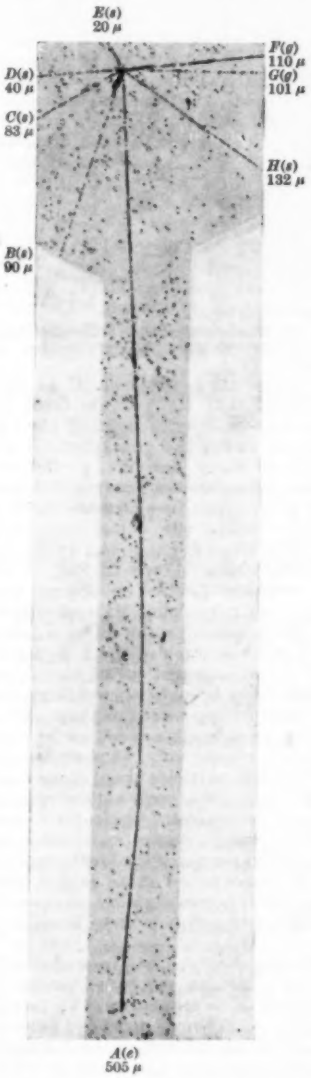


Fig. 1. Mosaic of twelve photomicrographs showing the multiple disintegration of a nucleus of silver or bromine. The different tracks are not all in the same plane and, with objectives of high aperture, several photographs must be taken to obtain a complete representation of the subject

The most striking feature of this second photograph is the 'hammer' track (*T*), in which the end of a heavily ionizing particle from the source is crossed by a second track in the form of a 'T'. It is possible that the cross-track is due to an α-particle of which the trajectory passes, by chance, within one micron of the end of the track of the particle from the 'star', and we observe tracks of approximately the same range and grain spacing throughout the plate. From the number of such tracks per unit volume of the emulsion we can, however, calculate the probability of the observed juxtaposition if it is to be explained as a chance event. We obtain a value less than 1 in 10^5, and we must therefore look for an alternative explanation.

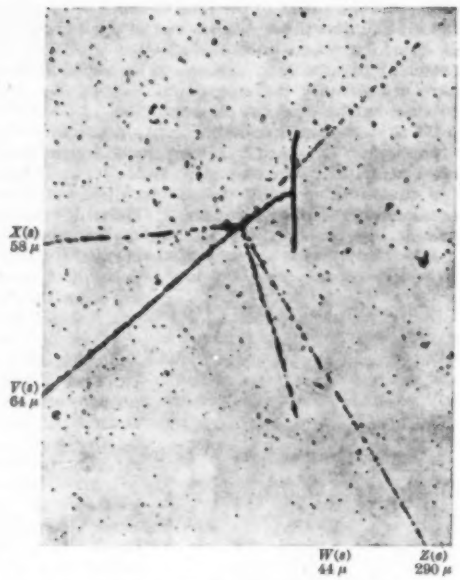


Fig. 2. Mosaic of six photomicrographs. The complete hammer track was obtained in a single photograph

A microscopic examination of track T at high magnification indicates that the particle from the exploding nucleus is more heavily ionizing than an α-particle. The track shows the characteristic distorted appearance—a wavy kris-like structure—which occurs when there are so many developing particles in it that their expanding filamentous form during development causes the column of silver grains to buckle. This effect is not found at the end of the long α-particle track shown in Fig. 1, and this is in accord with our general experience with α-particle tracks in the *C2* emulsion. We may therefore assume that the track is produced by a heavy nuclear splinter. The cross-track of the T is then to be attributed to the disintegration of the heavy particle, after it has been brought to rest, into two fragments which recoil in opposite directions. Since the two arms of the cross-track are of nearly equal length, 13·1 and 14·4 μ respectively, we must assume, on this view, that the two particles are of equal mass. If, as the simplest example of such a disintegration process, we assume the nuclear fragment to be an excited Be^8 nucleus which decomposes into two α-particles, the observed ranges of the tracks indicate that the energy in the excited state is 7·5 MeV. Serious difficulties arise, however, if we assume the fragment emitted from the explosion to be such an excited nucleus.

The speed of the recoiling nuclear fragment must be of the order of 2×10^9 cm. per sec. The time it takes to reach the end of its trajectory, 16 μ long, is therefore about 10^{-12} sec. Since the two component particles into which we regard it as decomposing are emitted in opposite directions, the velocity of the original Be^8 nucleus must have been small or zero at the moment of its decay. We must conclude that the life-time of the excited state is greater than 10^{-12} sec. Such a relatively long life corresponds to a width in the excited level of only a small fraction of an electron-volt. This is in contrast with the excited state of Be^8 at 2·9 MeV., which is known to have a width of several hundred KeV. and a correspondingly short life. We must therefore assume the existence of a metastable level in Be^8.

These difficulties can be overcome if we assume the original fragment to be a Li^8 nucleus. It has been shown that this nucleus suffers a β-decay, with a period of 0·8 sec., in which two α-particles appear, together with the electron. The α-particles have a continuous distribution in energy extending from low values up to 7·75 MeV. Our observations are therefore consistent with the assumption that the fragment from the exploding nucleus is Li^8.

Whether or not this particular observation is to be attributed to chance, our observations of several other equally striking events make it clear that multiple disintegration phenomena of this type cannot be accounted for in terms of conventional ideas in nuclear physics, and that we are entering a realm of great theoretical and experimental interest. It is clear that for such experiments the new photographic emulsions give us an instrument of considerable power. Among the other advantages of the method, which are gradually being recognized, we may point out that for this particular type of experiment it allows us to measure time intervals about a thousand times shorter than would be possible in similar experiments using the expansion chamber. The investigation is continuing.

We are indebted to Prof. J. Baillaud, director of the Observatory of the Pic du Midi, for permission to use the facilities of the Observatory and for much kindness and hospitality. To him, to our friend Prof. Max Cosyns, without whose assistance we should not have succeeded in making the exposures, and to Mr. C. M. G. Lattes, who assisted with the preparation of the material for the experiments, we wish to express our grateful thanks.

(*Note added in proof.*) We have observed a second multiple disintegration star which shows a 'hammer' track with equal branches at the 'T'. In other cases we found that the nuclear fragment decays into two and sometimes three fragments before coming to rest.

G. P. S. Occhialini
C. F. Powell

H. H. Wills Physical Laboratory,
University of Bristol.
Dec. 17.

[1] Powell, Occhialini, Livesey and Chilton, *J. Sci. Instr.*, **23**, 102 (1946).
[2] Heitler, Powell and Heitler, *Nature*, **146**, 65 (1940).
[3] Blau and Wambaker, *Sitz. Acad. Wien*, **146**, 623 (1937).
[4] Schopper and Schopper, *Phys. Z.*, **40**, 22 (1939). For other references see Shapiro, *Rev. Mod. Phys.*, **13**, 58 (1941).
[5] Hazen, *Phys. Rev.*, **65**, 67 (1944).
[6] Lattes, private communication.

A Theory of the Control of Twinning in Quartz

In a previous communication in *Nature*[1] some experiments in connexion with the controlled alteration in the twin boundaries of electrically twinned quartz have been described. The following theory satisfactorily accounts for the production of substantially single-crystalline specimens by the application of a torque at temperatures somewhat lower than the α-β transition point (573° C.).

If a plate of twinned material is cut parallel to an arbitrary direction relative to the crystallographic axes and then twisted about an axis parallel

to its length, the elastic energy per unit volume stored in each of the two individuals constituting the twin is different. The crystal of the first orientation in the twin may be more easy to twist than that of the second orientation, and will, in consequence, have more elastic energy per unit volume. According to the present theory, that orientation tends to predominate after the thermal and mechanical treatment which permits the crystal to twist as far as possible under a given torque.

This may be expressed quantitatively in the following manner. The expression for E, the elastic energy per unit volume of the crystal, will be of the form

$$E = \Sigma \frac{1}{2} t_{ik} r_{lm},$$

where t_{ik} and r_{lm} represent the stress and strain components respectively, and the summation is to be made over all the values for which i, k, l and m are independently made equal to 1, 2 and 3. This complete expression is too complicated to evaluate in most practical cases, but for torque applied to a long thin bar it is possible to simplify it. The predominant stress component for this type of experiment is a shear, tending to make a square drawn on the surface of the plate, with one edge parallel to the length of the plate, turn into a rhombus. The expression for E then becomes,

$$E = t'_{23} r'_{23},$$

where the X_3' axis is chosen parallel to the length of the bar and the X_2' axis parallel to the breadth.

Now since $s'_{23} \ll s'_{44}$, $r'_{23} = s'_{44} t'_{23}$, if all stress components other than t'_{23} may be neglected.

$$\text{Thus } E = s'_{44} (t'_{23})^2.$$

The orientation of the crystal in one part of the twin is derived from that in the other part by a rotation through 180° about the trigonal axis. The modulus s'_{44}, which applies to one part of the twin, differs in magnitude from the modulus s''_{44}, which applies to the other part of the twin in the same crystal plate. The change of energy per unit volume in changing from one orientation to the other is therefore ΔE, where

$$\Delta E = (s''_{44} - s'_{44}) (t'_{23})^2.$$

From the standard expression for s'_{44} the value of $s''_{44} - s'_{44}$ may be evaluated in terms of the angles ξ and θ, where ξ is the angle between the projection of the normal to the major surface of the plate on to the (00•1) plane, and the diad axis and θ is the angle between the same normal and the trigonal axis. This value is given by the equation,

$$s''_{44} - s'_{44} = -4 s_{14} \sin 2\theta . \sin 3\xi.$$

The geometrical model which can be constructed from this equation, by making each radius vector defined by ξ and θ of length equal to $(s''_{44} - s'_{44})$, has the form and symmetry of the figure derived experimentally and published in the previous communication[1]. Further, the experimentally observed direction of the electric axis in a crystal untwinned by the application of a torque agrees with that required by the theory. There appears to be no direct determination of the variation of s_{14} with temperature over the whole range 20°–573° C., but, if this variation is similar to that of the other elastic moduli which have been measured, it is not likely to alter the applicability of the theory here proposed until a temperature close to 573° C. is reached. A satisfactory theory is therefore given of the behaviour under torque of twinned plates of various orientations having their lengths perpendicular to the trigonal axis.

Following on the lines of the above theory, Mr. L. A. Thomas, of the Research Laboratories of the General Electric Co., Ltd., Wembley, has calculated the expression for $s''_{44} - s'_{44}$ for a plate of completely general orientation, thus including the case of plates having their lengths inclined to the diad axis. When applied to R-cut and r-cut plates having their lengths inclined at an angle of 45° to the diad axis, the agreement between the theory and experiment still holds. The theory shows that the sign of ΔE is reversed relative to that in plates of otherwise the same orientation but having their lengths parallel to the diad axis. This corresponds to the experimental fact that in two R-cut plates, one having its length parallel to the diad axis and the other having its length at 45° to this axis, complementary orientations are stable under the torque-and-heat treatment. This agreement between the simple theory and experiment is obtained in spite of the fact that, on twisting plates of such general orientation, bending occurs as well as twisting. It would not have been surprising if the simple theory outlined above had proved inadequate for plates of general orientation.

This work, of which a fuller account will be published elsewhere, has been done in co-operation with the Research Laboratories of the General Electric Company, Ltd., Wembley, and I am grateful to the Director for permission to publish. I also wish to acknowledge my indebtedness to Mr. R. S. Rivlin for valuable discussions on this subject.

W. A. Wooster

Brooklyn Crystallographic Laboratory,
Cherry Hinton Road,
Cambridge.
Nov. 30.

[1] Wooster, W. A., and Wooster, Nora, *Nature*, **157**, 405 (1946).

Crystal Structure of Copper Butyrate Monohydrate

Very few soaps or other similar substances have been examined by means of the X-ray single-crystal technique because of the difficulty of obtaining crystals which are large enough, and particularly crystals which are thick enough. Consequently, there are few data on the unit cell dimensions. Copper butyrate, however, when crystallized by allowing an acetone solution to evaporate at room temperature, gives unusually large and comparatively thick crystals in the form of six-sided plates frequently twinned on the large face. They are of a deep green colour, and on exposure to the air for a day or so the faces become dull, the crystals ultimately disintegrating.

Dehydration experiments carried out in an atmosphere with a partial water-vapour pressure of 13 mm. mercury showed that one molecule of water was lost between 42° and 47° C. Analytical data also confirmed the presence of water of crystallization.

According to Groth[1], the monohydrate is described as triclinic pinakoidal ($a : b : c = 1{\cdot}6921 : 1 : 0{\cdot}9993$, $\alpha = 88° 55'$, $\beta = 123° 51'$, $\gamma = 88° 25'$). The present crystals, however, are monoclinic, the large face being {001}. Rotation, oscillation and moving-film photographs were taken about the three principal axes and about the diagonal of the bc face of the unit cell using copper $K\alpha$ radiation. The unit cell dimensions are as follows :

$a = 25{\cdot}12$ kX.; $b = 14{\cdot}65$ kX.; (c) 26·79 kX.; $\beta = 109{\cdot}7°$; d (001) = 25·23 kX. Density (obs.) = 1·44 gm./cm.^{3}; density (calc.) = 1·45 gm./cm.^{3} (assuming 32 molecules of $(CH_3.CH_2.CH_2.COO-)_2$ $Cu.H_2O$ per unit cell).

The observed halvings were $\{hkl\}$ when $(k + l)$ is odd and $\{h0l\}$ all halved.

The space group is, therefore, $C_s^4 - Aa$ or $C_{2h}^5 - A2/a$. In the former space group, four asymmetric units are necessary, so that each unit would consist of eight molecules, whereas only four molecules per asymmetric unit are necessary in the latter space group. It is rather unusual for such a large number of molecules to be required.

I am indebted to Mr. Lang for preparing this compound, and to Dr. Vand and Mr. Lomer for carrying out the dehydration experiments. I wish to thank the director of the Chester Beatty Research Institute of the Royal Cancer Hospital (Free) for the loan of some apparatus, and the directors of Lever Brothers and Unilever, Ltd., for permission to publish these results.

JOHN IBALL

Research Department,
Lever Brothers and Unilever, Ltd.,
Port Sunlight, Cheshire.
Nov. 25.

[1] Groth, P. H., "Chemische Krystallographie", **3**, 245.

Response of Photoconductive Lead Sulphide Cells

IN a recent communication, the possibility of using photoconductive lead sulphide cells for the measurement of rapidly varying surface temperatures has been emphasized[1]. For this purpose it is, of course, desirable that the response time of the measuring instrument be sufficiently small, and it is therefore of interest to see whether on theoretical grounds it is possible to decrease the response time of the cells. In this connexion it is important to remember that the conduction electrons can be captured both by the ionized impurities (n per c.c.), the number of which increases with increasing temperature, and by interstitial ions. At ordinary temperatures the equilibrium number of the latter (Frenkel defects) is very small; however, under suitable conditions of manufacture, a large number (M per c.c.) corresponding to a high-temperature equilibrium can be 'frozen-in'. The number of conduction electrons released by radiation (I per c.c. per sec.) and heat agitation (A per c.c. per sec.) is then determined by the equation

$$\frac{dn}{dt} = I + A - Bn(n + M),$$

the capture coefficients of the ionized impurities and interstitial ions being assumed equal for the sake of simplicity. The time t_α taken to obtain the fraction α of the full asymptotic response is, therefore, given by

$$2B(n_0 + \tfrac{1}{2}M)\, t_\alpha = \frac{1}{\delta} \log \frac{\delta + 1 + (\delta - 1)\alpha}{(\delta + 1)\,(1 - \alpha)},$$

where

$$\delta = \sqrt{1 + \frac{I}{B(n_0 + \tfrac{1}{2}M)^2}} = \sqrt{1 + \frac{(n_\infty - n_0)\,(n_\infty + n_0 + M)}{(n_0 + \tfrac{1}{2}M)^2}};$$

$$n_0 = n\,(t = 0), \qquad n_\infty = n\,(t = \infty).$$

Hence, if $M \gg n$,

$$t_\alpha = \frac{1}{BM} \log \frac{1}{1 - \alpha},$$

whatever I may be.

On the other hand, if $M \ll n$,

$$t_\alpha = \frac{1}{2Bn_0} \log \frac{1}{1 - \alpha} \text{ for small } \delta - 1,$$

$$t_\alpha = \frac{1}{2Bn_0\delta} \log \frac{1}{1 - \alpha} = \frac{1}{2\sqrt{IB}} \log \frac{1}{1 - \alpha} \text{ for large } \delta - 1.$$

As B varies probably only slowly with temperature, the first formula shows that in the case $M \gg n$ the response time is almost independent of temperature but varies inversely as M. As distinct from this case, the response time decreases exponentially with increasing temperature of the cell if $M \ll n$, owing to the exponential increase of n_0 for semi-conductors. The case of large $\delta - 1$ requires too high intensities of radiation to be important in practice.

It is to be expected that the case of a large number of 'frozen-in' capturing centres will be realized in practice if there is a large and rapid drop in the diffusion coefficient of the Frenkel defects during the manufacture of the cell[2]; for example, if the lead sulphide film is obtained by evaporation at a high temperature and sublimation on a cool support. The higher the temperature at which the film is formed, and the cooler the support, the larger M will be, that is, the smaller the response time t_α. The other case, $M \ll n$, can be expected to apply to cells made at ordinary temperatures, for example, by chemical precipitation.

It must be pointed out that the decrease in response time is accompanied by a corresponding decrease in response (signal), the asymptotic number of photoelectrons being given by

$$n_\infty - n_0 = \frac{I}{2B(n_0 + \tfrac{1}{2}M)} = \frac{It_\alpha}{-\log(1 - \alpha)}.$$

Conversely, the formula shows that, at a loss of speed of response, the sensitivity of the cells can be increased by the methods indicated.

Details and comparison with experiments will be given elsewhere. I have to thank the Director-General of Scientific Research (Defence), Ministry of Supply, for permission to publish the present communication.

W. A. HEPNER

Department of Mathematics,
Imperial College of Science and Technology,
London, S.W.7. Oct. 17.

[1] Lee, E., and Parker, R. C., *Nature*, **158**, 518 (1946).
[2] Mott and Gurney, "Electronic Processes in Ionic Crystals" (Oxford, 1940).

Temperature Dependence of the Intensities of Raman Lines

I HAVE undertaken the critical and exhaustive study of Placzek's polarizability theory of Raman scattering. My investigations have been carried out both with solids and liquids, and the following observations made: (1) The intensity of the Stokes lines decreases with the rise of temperature, while according to the theory there should be an increase. (2) The intensity of the anti-Stokes lines, in general, increases with the increase of temperature, but not to the extent that would be expected from Placzek's theory. (3) The intensities of the Stokes and the

anti-Stokes lines tend to meet each other at some finite value, while from the theory we should expect the intensities of the Stokes and the anti-Stokes lines to become large at high temperatures and to tend to meet each other at infinite intensity. (4) The ratio of the intensities of the Stokes and anti-Stokes lines, at all temperatures, is in agreement with the result expected from Placzek's theory.

The polarizability of a molecule may be expanded as a series

$$L(q) = L_0 + \sum_j \left(\frac{\partial L}{\partial q_j}\right)_0 q_j + \tfrac{1}{2}\sum_{jk}\left(\frac{\partial^2 L}{\partial q_j\,\partial q_k}\right)_0 q_j q_k + \ldots,$$

where the suffix 0 refers to the equilibrium configuration, q_j, q_k, etc., are the various normal coordinates of the molecule, and a particular set of values of q_j, q_k, etc., define a configuration q of the molecule. The conclusions from Placzek's theory are arrived at by taking the factor $\left(\frac{\partial L}{\partial q_j}\right)_0$ as constant at various temperatures. Taylor's expansion is valid only in the close vicinity of the equilibrium configuration. But as the temperature is increased, the amplitudes become larger, and we can no longer assume that Taylor's expansion, which is taken in the neighbourhood of the equilibrium configuration, is valid. Therefore, $\left(\frac{\partial L}{\partial q_j}\right)_0$ cannot be regarded as constant. It will decrease rapidly with the increase of temperature. The observed results can be explained on this basis.

A detailed explanation will be published elsewhere.

K. Venkateswarlu

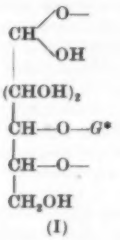
Andhra University,
Waltair, S. India.
Nov. 12.

Structure of Starch and Cellulose

Although the characteristic features of the chemistry of starch and cellulose are satisfactorily represented by the commonly accepted structures involving chains of glucopyranosido residues, which are unbranched in cellulose and amylose, but branched in amylopectin, certain difficulties remain to be explained. These include, for example, the exact nature of the relationship between the amylose and the amylopectin components of the starches, and the reasons for the different behaviour of cellulose on methylation in the presence and in the absence of oxygen respectively.

In an attempt to overcome very real difficulties of this kind, Pacsu and Hiller[1] have recently advocated a novel structure for these polysaccharides based on the assumed occurrence of a small proportion of non-cyclic hemiacetal linkages. This is a modification of the Tollens acetal structure for cellulose, and the essential feature of it as applied to starch is shown in (I), which depicts a maltose residue in a hemiacetal form serving as a link between long chains of 1 : 4 linked glucopyranosido residues. The glucose residue marked with an asterisk is an end-group, and Pacsu and Hiller apparently postulate a sufficient number of these cross-linkages to account for the number of end-groups as determined by the methylation method. It is not possible, therefore, to decide on the results of methylation experiments alone whether or not such a formula is valid for a starch.

Other methods of approach to the problem of end-group determination have recently been developed, and by application of one of these we have obtained evidence from which it appears that the type of linkage suggested by Pacsu and Hiller does not occur in starches. Inspection of (I) reveals that the presence of hemiacetal linkages increases the number of contiguous hydroxyl groups at which oxidative attack by the periodate ion is possible, with the result that from the structure shown in (I) three molecules of formic acid would be formed for every terminal glucose residue (G^*). Actually, on the basis of the much more complicated detailed formula depicted by these authors, considerably more than three molecules of formic acid per end-group would be liberated, with the simultaneous formation of a large number of fragments of smaller molecular weight.



(I)

It has been found, however, by use of methods elaborated recently for the quantitative liberation and estimation of formic acid in periodate oxidations of polymeric glycosides[2], that starches yield only one molecule of formic acid per end-group. This result is in agreement with the expected value if amylopectin possesses the 'laminated' structure[3], but is incompatible with Pacsu and Hiller's formula.

In other respects also the newly proposed structure appears to be incapable of reconciliation with experimental observations. For example, investigations on the kinetics of the 'disaggregation' of starch have shown that the bonds broken in the reaction have the stability of glycoside links towards acid, and require no novel type of bonding to explain their properties[4]. Furthermore, it is difficult to see how the results of enzymic hydrolysis and dextrin formation could be explained by structures involving hemiacetal linkages of the type shown in (I).

T. G. Halsall
E. L. Hirst
J. K. N. Jones

University, Manchester.
Nov. 29.

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Effects of Organic Arsenic Compounds on Tissue Enzymes and Proteins and on Tissue Metabolism

In connexion with recent interesting reports, both in Great Britain and in the United States, on the relationship between organic arsenicals and enzymes containing thiol groups, we would like to take the opportunity of directing attention to some early observations of our own, incorporated in a report to the Medical Research Council in November 1940.

The following extract from this report gives our conclusions based on investigations, carried out in the Cardiff City Mental Hospital during 1938, 1939 and early 1940, on the effects of organic trivalent and pentavalent arsenic compounds on proteins and enzymes.

"(1) Reversible equilibria exist between pentavalent arsenic compounds (such as tryparsamide) or trivalent arsenic compounds (such as arsphenamine and derivatives of phenylarsenoxide) and purified tissue proteins. The affinity of organic arsenoxides to the proteins is far greater than that of pentavalent arsenic compounds. Affinity constants have been measured and new methods for analysis of As^{III} and As^{V} in presence of proteins elaborated. Compounds of the type *R*.As.O combine reversibly with —SH groups of the protein and with other as yet unknown groupings.

"(2) Certain compounds of the type *R*.As.O (e.g., meta-amino-*p*-hydroxyphenylarsenoxide, also known on the market as 'mapharside') combine reversibly with —SH enzymes. They can be regarded as specific inhibitors of this class of enzymes, which includes urease, succinic dehydrogenase and choline esterase. It is proved for the first time by this means that choline dehydrogenase is an —SH enzyme. Enzymes known not to possess —SH groups as part of their active centres, e.g., invertase, catalase, lactic dehydrogenase, cytochrome oxidase are unaffected by *R*.As.O. The toxicity of *R*.As.O to enzymes is neutralised by the addition of —SH compounds, e.g., cysteine, in large excess. These condense with *R*.As.O to form easily dissociated compounds, and excess —SH is required to keep most of the —AsO in the form of the inert —As(S—)(S—) derivative.

"Compounds of the type *R*.As.O and *R*.As.Cl_2 also inhibit vigorously the respiration of intact cells in presence of glucose and sodium pyruvate. Such cells vary from intact brain tissue to bacterial suspensions. The oxidation of pyruvate and possibly other ketonic acids is greatly inhibited, and ketonic acids accumulate. The addition of —SH compounds in excess neutralizes *R*.As.O inhibition of the metabolism of intact cells.

"Compounds of the type *R*.As.O and *R*.As.Cl_2 are also highly bactericidal but the addition of —SH neutralises the lethal action.

"(3) Pentavalent arsenic compounds, e.g., tryparsamide and atoxyl, are reduced by —SH compounds (e.g., cysteine, glutathione) under biological conditions to the highly toxic trivalent —AsO derivatives. This may be demonstrated by the effects of the products of reduction on —SH enzymes (e.g., urease) and on intact cells. The reduction of tryparsamide in the body is doubtless accomplished by the —SH bodies (e.g., glutathione) present."

This work was undertaken as part of a programme to elucidate the mechanism of action of arsenicals in the treatment of syphilis of the central nervous system, and part of it was carried out with the assistance of Mr. W. J. Clarke.

The publication of these results was not allowed during the War for security reasons. Owing to war work we became separated, and only recently have we had the opportunity of reconsidering our early work for the purpose of publication.

The experimental results upon which the above conclusions have been reached will, it is hoped, be published shortly. We are much indebted to the secretary of the Medical Research Council for permission to publish the extract of the report in question.

J. J. Gordon
J. H. Quastel

University College, Cardiff.
Dec. 17.

Splitting of Phosphocreatine

It is generally assumed that when phosphocreatine is hydrolysed either enzymatically or spontaneously, the end products are creatine and phosphoric acid. This, however, is not always found to be the case. When phosphocreatine is hydrolysed at 38° in saturated picric acid, about 10 per cent of the substance is converted into creatinine (Fig. 1). Under these conditions, creatine is not transformed into creatinine. Obviously phosphocreatine has a certain spontaneous tendency to ring formation. If heated to 100° either in picric acid or hydrochloric acid, there is a rapid formation of creatinine, followed by a linear increase due to the reaction creatine – creatinine (Fig. 2). If the two curves are subtracted, a curve of much the same appearance as Fig. 1 results. Whether picric or hydrochloric acid is used for hydrolysis is of no importance.

The phenomenon described may possibly be developed into a specific method for the estimation of phosphocreatine in blood and other tissues. Generally this substance is estimated as the difference ('direct determinable' P — 'true' inorganic P), thus neglecting other labile phosphorus compounds which may be present.

These experiments may perhaps throw some light on the creatinine formation in living organisms. It is well established that the daily excretion of creatinine

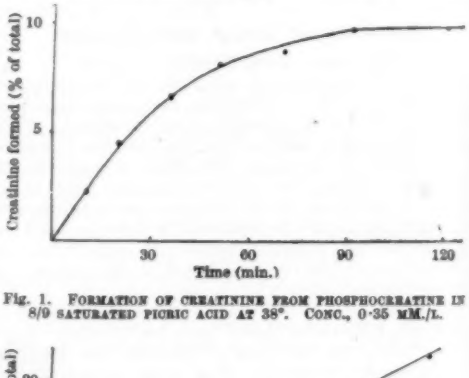

Fig. 1. Formation of creatinine from phosphocreatine in 8/9 saturated picric acid at 38°. Conc., 0·35 mM./l.

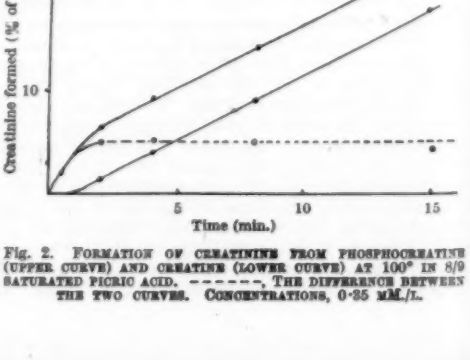

Fig. 2. Formation of creatinine from phosphocreatine (upper curve) and creatine (lower curve) at 100° in 8/9 saturated picric acid. – – – –. The difference between the two curves. Concentrations, 0·35 mM./l.

is rather closely proportional to the total amount of muscle tissue and independent of muscular activity. This may be explained if it is assumed that there is a spontaneous breakdown of phosphocreatine resulting in the formation of some creatinine. The phosphocreatine breakdown through specific activity yielding the energy-rich phosphate group to some acceptor can readily be imagined to give rise to no creatinine formation, thus explaining why the creatinine output is independent of muscular activity.

Another problem which may perhaps be attacked on the basis of the present observation is the active renal secretion of creatinine.

According to the hypothesis that a necessary condition of renal tubular secretion is that the substance is an acid[1], creatinine should not be secreted; and it is in fact the only substance not found to obey this rule, at least in mammals.

Rehberg[2] has suggested that phosphocreatine, known to occur in plasma after the injection of creatinine[3], may be converted into creatinine in the tubular cells and thus be responsible for part of the urinary creatinine. This suggestion seems to find support in the observation that phosphocreatine may form creatinine spontaneously. The tubular cells are supposed to exhibit a strong non-specific phosphatase activity, thus making possible a partial conversion of phosphocreatine into creatinine. That phosphocreatine should be absorbed from the blood stream by the tubular cells is well in accord with the hypothesis mentioned[1].

Frank Lundquist

Institute of Legal Medicine,
University of Copenhagen.
Dec. 3.

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[2] Rehberg, P. B., XVI Int. Physiol. Kongress, *Kongressber.*, 1, 4 (1938).
[3] Abdon, N-O., *Kungl. Fysiograf. Sällsk. i Lund Förhandl.*, 5, 14 (1935).

Preparation of Cell-free Tryptophanase

In our earliest studies on the tryptophanase complex[1] active non-viable suspensions of *E. coli* were used. These had been sterilized by shaking with chloroform, 1 volume to 2 volumes of suspension. The mixture was shaken vigorously to 200 r.p.m. for 4 hours.

An active dry enzyme preparation was also prepared by precipitation of the cells with 66 per cent alcohol (at 0°) and subsequent washing with ice-cold absolute alcohol. Since at that time we were mainly concerned with the mechanism of the reaction, further work was not attempted; though occasional studies on the supernatants from viable cells suggested that the enzyme complex could be obtained as a cell-free preparation. More recently we have been concerned to know more of the nature of the enzyme complex, and the following represents the preparation of such a cell-free preparation and which, moreover, can be divided into a dialysable and non-dialysable portion.

Cells grown for 22 hours at 37° on a tryptic digest of cæsin solidified with agar were harvested, washed and filtered through glass wool. Thick creamy suspensions thus obtained were cooled in ice and poured into five volumes of ice-cold acetone with constant stirring. The flocculated cells were allowed to settle and then filtered off with gentle suction on a Buchner funnel, washed successively with acetone, acetone and ether, and finally ether, and dried in a desiccator.

Tests were made with buffer solutions of *p*H 5, 7 and 9 to extract the enzyme from the powder. After overnight extraction, the suspensions were centrifuged and supernatants adjusted to *p*H 7·4. Activity of extraction was nil at *p*H 5, faint at 7 and more marked at 9.

The present technique employed is overnight extraction with borate buffer *p*H 8·6 using 20 mgm. acetone-dried powder per ml. buffer. Whereas the optimum *p*H for the reaction by the intact organism is 7·6, the cell-free enzyme has an optimal *p*H range of 8–8·5. The activity obtained from such cell-free extracts has been, at the maximum, approximately 25 per cent of that obtained from intact organisms, presumably due to destruction of some portion(s) of the tryptophanase complex by acetone drying.

Dialysis of the cell-free extract has been performed, and both dialysate and protein portion have been shown to be inactive by themselves. When added to one another activity was regained.

Work is now in hand on the elucidation of the various factors of the enzyme complex, and a full report will be published at a later date.

E. A. Dawes
J. Dawson
F. C. Happold

Department of Biochemistry,
School of Medicine,
Leeds, 2.
Dec. 4.

[1] *Biochem. J.*, **29**, 1918 (1935).

Yeast and Rickets

In his address to the Seventh Congress of Biological Chemistry in Liège on October 3–6, 1946, Dr. H. D. Kay summarized some experiments on feeding pigs with yeast, carried out during the War at the National Institute for Research in Dairying in Reading[1]. It was found that when the total food ration contained 8 per cent dried yeast, some of the animals developed stiffness and lameness, and were finally unable to stand. If the diet contained 20 per cent yeast, this condition developed rather rapidly in all pigs. X-ray examination of the bones indicated that the pigs were, in fact, suffering from rickets. The rachitic symptoms could be prevented by a sufficient supply of vitamin D, and could be almost completely prevented by increasing the calcium carbonate content of the diet from 1·5 to 4 per cent. When the yeast phosphorus was replaced by the corresponding amount of sodium phosphate phosphorus, no symptoms were produced.

During a recent visit to England, I discussed this problem with the Reading workers, who were now of the opinion that the rachitogenic effect of yeast might be connected with the high phytic acid content in the diet. The results of our experiments, which show that dried yeast is a strong inhibitor of the enzyme phytase, support this hypothesis.

The experiments were made on a crude enzyme solution extracted from rye bran. 25 ml. of the solution correspond to the phytase activity of about 15 gm. barley. The yeast used was dried brewers' top-yeast. The system contained 25 ml. enzyme solution and 72·0 mgm. phytate phosphorus, as pure sodium phytate; concentration of acetate buffer, 0·2 *M.*; total volume, 100 ml.; *p*H, 5·20 ± 0·05; temp. 30° ± 0·1° C.; time of reaction 2 hr., at the end of which 10 ml. was taken out to control the *p*H

and 10 ml. 5 *N* hydrochloric acid added to end the enzymatic reaction. Phytate phosphorus was determined in the centrifugate. When yeast was added, it was first shaken for 1 hr. with 50 ml. 0·2 *M*. acetate buffer and the *p*H readjusted before adding enzyme and substrate. The yeast extract was made by shaking 20 gm. yeast with 150 ml. 0·2 *N* hydrochloric acid for 2 hr. The centrifugate was neutralized with sodium hydroxide and diluted so that 10 ml. is approximately equivalent to 1 gm. yeast. 10 ml. of the extract contained 5·5 mgm. inorganic phosphorus.

INFLUENCE OF DRIED YEAST ON PHYTASE ACTIVITY

No.	Addition	Phytate P split (mgm.)	Inhibition (per cent)
1	None	41	0
2	10 gm. fresh bakers' yeast	44	10
3	30 mgm. P as pot. phosphate	37	10
4	1 gm. dried yeast	31	24
5	3 " " "	22	46
6	5 " " "	10	76
7	10 ml. yeast extract	33	20
8	30 " " "	24	41
9	50 " " "	12	71
10	No enzyme	0	—
11	No enzyme ; 3 gm. dried yeast	0	—

If the phytase activity of the fodder and of the bacteria in the intestinal canal is as highly inhibited by yeast as the above experiments seem to indicate, the results of the feeding experiments obtained in Reading may become more intelligible.

E. HOFF-JØRGENSEN
Universitetets biokemiske Institut,
Juliane Maries Vej 30,
Copenhagen, Ø.
Dec. 4.

[1] Braude, R., Kon, S. K., and White, E. G., *J. Com. Path.*, **53**, 161 (1943) ; **54**, 88 (1944).

Isolation of Phloridzin from Apple Seeds

IN a recent communication[1], the preparation of apple seed extracts capable of stimulating the development of unfertilized tomato ovaries was described. Treatment of the seeds with water at 100° C. for 15 minutes gave, on cooling, a crystalline substance which preliminary tests indicated was possibly glycosidic in nature. While not possessing the fructigenic activity shown by the aqueous filtrate, this compound disappeared at the stage when the extracts were no longer active, and consequently further investigation was indicated.

Hydrolysis with *N*/10 sulphuric acid gave glucose, characterized by the formation of the osazone and the β-penta-acetate, and a phenolic substance, m.p. 259–260° C., which gave elementary analytical results corresponding to the formula $C_{15}H_{14}O_5$. A comparison of the phenol, its tetra-acetate and trimethyl ether[2] with authentic specimens kindly supplied by Prof. A. Robertson confirmed its identity as phloretin[3] and the glucoside as phloridzin[4]. This latter is known to occur in the bark (especially the root-bark) and leaves of apple trees, but has not hitherto been reported in the seeds. In this connexion the yields are extremely interesting, being as much as 8 per cent (of seed fresh weight) four weeks after petal-fall, and decreasing to less than 1 per cent after eight weeks ; ten weeks after petal-fall, phloridzin could no longer be isolated.

Further work involving an examination of the relationship (if any) between phloridzin and the hormone, and possible isolation of the latter, is proposed.

My thanks are due to Dr. L. C. Luckwill for supplying most of the glucoside and for carrying out the physiological tests.

D. WOODCOCK
Long Ashton Research Station,
University of Bristol.
Dec. 4.

[1] Luckwill, L. C., *Nature*, **158**, 663 (1946).
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[3] Fischer, E., and Nouri, O., *Ber.*, **50**, 611 (1917).
[4] Muller, A., and Robertson, A., *J. Chem. Soc.*, 1170 (1933).

Medium Suitable for the Cultivation of Meredith's Actinomycete

IN our study of the antibiotic properties of certain Actinomycetes[1], it has been one of our endeavours to devise a cheap medium for the growth of these organisms which would contain a minimum of organic and inorganic substances likely to interfere with the extraction of the antibiotic. Of the many varieties of liquid and solid media tested, we have finally adopted the following :

Autolysed yeast extract	0·25 per cent
Glucose	0·5 per cent
Distilled water	to 100 ml.

The reaction adjusted to a *p*H of 6·0 to 7·0.

Increasing the yeast extract content of the media beyond 0·25 per cent leads to a reduction in antibiotic production.

As for the yeast extract to be chosen, it would appear that any reasonably carefully prepared commercial brand is suitable. The three actually tried, 'Marmite', 'Gye' and 'Yeastrel', all gave the same degree of growth and antibiotic production.

Our medium has been tried also for the growth of *Actinomyces griseus*. It was found eminently suitable for this organism, yielding growth and production of antibiotic equal to that obtained by the media usually employed in the cultivation of this organism.

It may be of interest to record that the growth-liquor of our antibiotic-producing Actinomycete is highly active against a culture of *Cerospora nicotiana* Ell. and Ev., obtained from the Baarn Type Culture Collection, and claimed to be responsible for the spotting of the tobacco leaf.

A. C. THAYSEN
MURIEL MORRIS
Colonial Microbiological Research Institute,
Port of Spain,
Trinidad.
Dec. 5.

[1] Thaysen and Butlin, *Nature*, **156**, 781 (1945).

Connective Tissue Cementing Substance

IN 1876, W. Flemming[1] described a cementing substance associated with the fibrils of loose connective tissue. This finding is of considerable importance in relation to modern conceptions of the chemical structure of collagen and other fibrous proteins.

There is reason to suppose that the long-chain molecules of which collagen fibres are composed are mainly held together by lateral bondings of an electrovalent character. It has been pointed out by the late Dr. Jordan Lloyd[2] that, since such bondings are readily

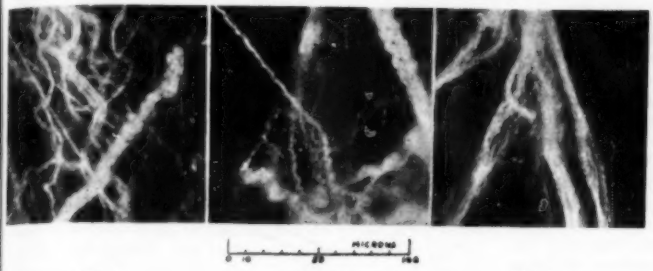


Fig. 1 Fig. 2 Fig. 3

Fig. 1. DARK GROUND PREPARATION SHOWING THE COMPACT BUNDLES OF COLLAGEN FIBRILS IN DISTILLED WATER AT *p*H 7·0. AN ELASTIC FIBRE MAY ALSO BE SEEN RUNNING DOWNWARDS AND DIAGONALLY FROM THE LEFT UPPER CORNER OF THE PHOTOGRAPH

Fig. 2. COLLAGEN BUNDLES AT *p*H 3·8. THEY ARE NARROW AND MARKEDLY CRIMPED

Fig. 3. COLLAGEN BUNDLES IN *M*/2 CONCENTRATION OF SODIUM CHLORIDE. THE BUNDLES ARE WIDE AND STRAIGHT AND THEIR CONSTITUENT FIBRILS EASY TO IDENTIFY. IN SUCH CONCENTRATIONS OF NEUTRAL SALTS THE INDIVIDUAL FIBRILS FREQUENTLY SHOW BROWNIAN MOVEMENT

susceptible to ionic penetration, it is somewhat surprising that when collagen bundles are removed from the animal body and teased out in water they show no tendency to dissolve but remain as coherent structures for a considerable time. Dr. Jordan Lloyd suggested that the larger collagen bundles are held together by sheaths composed of another fibrous protein, the reticular tissue. Specialized sheaths of this kind may certainly be shown to surround relatively large collagenous structures such as the tendons in the tail of the rat; but it is difficult to visualize such an arrangement in the much smaller bundles of loose connective tissue which in small animals vary from 2 to 10 μ in diameter. My observations of the loose connective tissue of the rat furnish strong evidence that these smaller bundles owe their cohesion to the presence of an amorphous cementing substance within them, rather than to any sort of fibrillary wrapping.

After killing the animal, pieces of fascial connective tissue were placed directly into the fluid the effect of which was to be investigated. After half an hour at room temperature, they were mounted under a coverslip in the same fluid and examined with the dark-ground microscope. In distilled water, *p*H 7·0, the bundles of collagen fibrils appeared compact. Their constituent fibrils were not generally easy to identify. With increase in hydrogen ion concentration the bundles became more condensed, their optical opacity was greatly increased, there was great reduction in thickness, and they became coiled up and crimped. This effect was easily perceptible at *p*H 5·0. It was maximal between *p*H 4·2 and 3·8. With further increase in hydrogen ion concentration, acid swelling of the collagen began, and at *p*H values between 3·8 and 3·0 the appearances indicated the antagonistic action of two processes, namely, the contraction of the cementing substance and the swelling of the collagen. The irregular beaded swellings of collagen bundles in acids of strengths around 0·001 *N* would seem to be a resultant of these two antagonistic processes.

An effect contrary to that due to hydrogen ions was produced by neutral salts. Concentrations of, and greater than, *M*/8 caused relaxation of the substance cementing the fibrils together. The bundles became wide and straight, and their constituent fibrils could readily be identified. In some bundles the individual fibrils were seen to show Brownian movement.

The contrasted changes produced in the cementing substance by hydrogen ions on one hand and neutral salts on the other were found to be reversible up to the point at which acid-swelling of collagen occurred. Bundles swollen in acid became shrunken again after treatment with salt, but they did not recover their former fibrillary structure. They remained opaque and granular.

Fleming considered the cementing substance to be of mucinous nature. This was not confirmed. On the contrary, pieces of connective tissue treated with testicular extract and also pieces treated with purified streptococcal hyaluronidase did not lose the properties described above. Treatment with a phosphate buffer of *p*H 8·0 at 0° C. for several days failed to remove the cementing substance. There is strong evidence, however, that this substance is acted upon by trypsin. After immersion in a solution of trypsin for 24 hours at 20° C., connective tissue loses its coherence and elasticity. It may be teased apart like a piece of damp blotting paper. In pieces afterwards treated with fluids of appropriate hydrogen ion concentration and examined with the dark-ground microscope, the crimping of the bundles is markedly reduced or entirely absent.

The presence of cementing substance within the bundles has been particularly emphasized. Its existence outside the bundles is harder to demonstrate, but may be reasonably deduced from the fact that at hydrogen ion concentrations around *p*H 4·0 the connective tissue as a whole becomes opaque and that opaque granules appear outside the fibrils.

It is to be concluded that the collagenous bundles of loose connective tissue owe their cohesion largely to a cementing substance in which their constituent fibrils are embedded. This substance is a protein, since it is acted upon by trypsin. Its viscosity would appear to be progressively increased in concentrations of hydrogen ions ranging from neutrality to *p*H 3·8, and reduced in the presence of neutral salts in concentrations of, and above, *M*/8.

T. D. DAY

Department of Pathology,
St. Thomas's Hospital Medical School,
London, S.E.1.
Dec. 4.

[1] *Arch. mikr. Anat.*, **12**, 442 (1876).
[2] *J. Soc. Dyers and Col.*, **57**, 281 (1941).

Epidermal Thickness Following Oestrone Injections in the Mouse

THE cyclic variation in the mitotic activity of the epidermis of the adult female mouse, which is dependent on the cyclic activity of the ovary, is accompanied by coincident cyclic variation in epidermal thickness[1]. Thus, in the antero-dorsal region of the body, the highest rate of mitotic activity occurs during the pro-œstrous period, with the result that the epidermis is at its thickest in pro-œstrus and early œstrus. It has also been shown that the mitotic activity of the epidermis can be

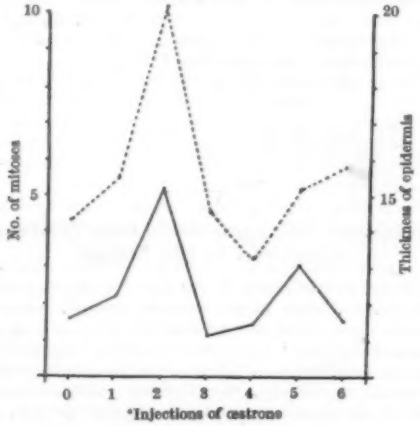
artificially stimulated by œstrone injections[2], and it would therefore seem probable that the same treatment would result in epidermal thickening. However, Hooker and Pfeiffer[3] have reported that injections of œstradiol benzoate result in a decrease of epidermal thickness, an effect apparently due to inhibited mitotic activity. An additional analysis of the effects of œstrone injections on the rate of cell division and thickness of the epidermis has therefore been made in an attempt to throw light on the apparent contradiction.

The injections were started on the first day of dioestrus, the time when both the mitotic activity and the thickness of the epidermis are at a minimum. At each injection 0·025 mgm. of œstrone in 0·25 c.c. of water was introduced into each mouse, and the injections were repeated at 12-hourly intervals for three days. Groups of five mice each were killed 12 hours after receiving from one to six injections, and each animal was also given 0·1 mgm. of colchicine 9½ hours before killing. The mitoses, mostly in the metaphase, were counted in 1 mm. lengths of anterodorsal epidermis cut at a thickness of 7 μ. Twenty counts were made for each individual, and thus for each group there were 100 counts, from which averages and standard deviations were calculated. In the same way the results regarding epidermal thickness summarize 100 measurements per group, the distance measured being from the base of the stratum germinativum to the free surface of the stratum corneum.

The results are recorded in the accompanying table and illustrated in the graph. From them it is evident that the induced mitotic activity was accompanied by an increase in epidermal thickness, the two maxima being reached simultaneously after two injections. Rapid cornification, combined with sloughing, apparently accounted for the fact that the thickness did not remain considerable after the rate of mitosis fell.

While these experiments lasted only three days, those of Hooker and Pfeiffer continued for a long period, the injections being given twice weekly. A comparison of the results indicates that although the mitotic activity and thickness of the epidermis are normally increased by œstrogenic substances, a prolonged excess of such substances leads to the opposite effect. The same is true of the sebaceous glands. Their mitotic activity and growth are normally stimulated by œstrogens[2]; but if the stimulation is unduly great and unnaturally prolonged, the opposite effect is produced[3]. Further, although the growth of hair presents special problems, it is interesting to note that here again the mitotic activity of the hair bulb is reduced by the continued administration of œstrogenic substances.

	Numbers of mitoses per mm. of epidermis	Thickness of epidermis (in μ)
Dioestrus: 1st day	1·65 ± 1·13	14·4 ± 4·2
Œstrone injections:		
1	2·26 ± 2·12	15·5 ± 2·99
2	5·12 ± 3·63	20·2 ± 4·37
3	1·14 ± 1·45	14·5 ± 1·94
4	1·41 ± 1·43	13·2 ± 2·59
5	3·02 ± 2·76	15·3 ± 2·51
6	1·64 ± 1·60	15·8 ± 4·13



RELATION BETWEEN MITOTIC ACTIVITY (CONTINUOUS LINE) AND THICKNESS (BROKEN LINE) OF MOUSE EPIDERMIS FOLLOWING ŒSTRONE INJECTIONS

HELENA F. BULLOUGH
Department of Zoology,
University of Sheffield.
Dec. 6.

[1] Bullough, H. F., *J. Endocrin.*, **3**, 280 (1943).
[2] Bullough, W. S., *Phil. Trans. Roy. Soc.*, B, **231**, 453 (1946).
[3] Hooker, C. W., and Pfeiffer, C. A., *Endocrin.*, **32**, 69 (1943).

Soil Sterilization on a Field-Scale

THE steam sterilization of soils is well known; for example, as carried out under glass for tomato growing—a practice which is now accepted as routine. As well as achieving a drastic diminution in the numbers of harmful bacteria, to the advantage of the surviving nitrifying bacteria, there is a marked increase in available nitrogen.

In the spring of this year, 'Gammexane' was mixed with fertilizer and sown with oats through a combine seed drill; this was on old lea with negligible wireworm and leatherjacket counts. The treated area revealed stronger, broader-leaved plants, and of a depth of green which made the control look undernourished. This difference was apparent until the oats were fully a foot long.

The same compound was applied on 'brairded' swedes, but this time for the purpose of mitigating the ravages of the turnip flea beetle; on this crop the 'Gammexane' was sown broadcast. The effect was very similar to that on the oats, namely, greater depth of colour and more vigorous plants. It is of interest to note that the weeds between the drills were also more vigorous than in the rest of the field.

From these observations, one may be justified in assuming that the chlorine liberated from the 'Gammexane' has effected a partial sterilization of the soil, and in consequence an increase in available nitrogen.

This opens up a field for wider investigation and research, and it is possible that in compounds of this nature we have, not only an insecticide of the first order, but also a sterilizing agent, easily handled and with unlimited possibilities within the industry.

ARCH. B. SMART
West of Scotland Agricultural College,
15 Southfield Road,
Kirkmuirhill,
Lanark.
Dec. 12.

COMMONWEALTH OF AUSTRALIA COUNCIL FOR SCIENTIFIC AND INDUSTRIAL RESEARCH

ANNUAL REPORT

THE nineteenth annual report of the Council for Scientific and Industrial Research, Commonwealth of Australia, covers the year ended June 30, 1945, and indicates the greater attention which was given to problems of post-war reconstruction, as, for example, in the use of the Soils Division's surveys of areas intended for closer settlement (Canberra: Commonwealth Gov. Printer). The report also refers for the first time to the Division of Radiophysics, which with its central laboratory at the University of Sydney was formed early in the War, and until the termination of hostilities was engaged solely on work for the Australian and American Fighting Services. In addition to representatives of the Australian Fighting Services, the Radiophysics Advisory Board included representatives of the Postmaster-General's Department and, later, of the Ministry of Munitions, while effective liaison was also established with Great Britain and the United States through the British Central Scientific Office at Washington. In addition to assisting the Services very considerably in technical training courses and facilities, the Division has been engaged in fundamental research associated with the design of radar equipment and in the investigation, development, design and manufacture to the prototype stage of radar and associated equipment required by the Armed Forces. A light-weight radar set was designed and constructed for the Royal Australian Air Force for air warning purposes, and in addition to investigations into the cause and incidence of super-refraction at relatively low heights in the atmosphere and ionospheric observations, the Laboratory has now initiated some work on possible applications in the field of navigational aids for civil aviation.

In addition to the account of the formation and work of this new Division, the report refers also to the conversion of three sections of the National Standards Laboratory to the status of Divisions of Metrology, of Electrotechnology and of Physics, respectively, while the former Division of Animal Health and Nutrition has been separated into two divisions, known as the Division of Animal Health and Production and the Division of Biochemistry and General Nutrition.

An important development during the year was the decision to undertake a comprehensive programme of research into building materials, including concrete and other materials for structures such as bridges, dams, etc. The Council has also accepted responsibility for work on flax processing, and is to be entrusted with an extensive programme of research and publicity for the wool industry; while as from April 16, 1945, the Council has taken over the Scientific Liaison Bureau.

Under the Division of Plant Industry, a laboratory for the study of pasture production under irrigation is being established in the area between the Murray and the Murrumbidgee Rivers, while other pasture investigations were concerned with pasture management, soil fertility, the establishment of pasture under cover crop, the control of Capeweed and other weeds. The Division also conducted trials of plants and seeds introduced from abroad, forage and pasture plant trials, as well as investigations on Guayule rubber, take-all disease of wheat, native plants as sources of medicinal drugs and insecticidal substances, the opium alkaloids, tobacco, the potato virus and varietal resistance to leaf roll, spotted wilt and fusarium wilt of tomato, the retting of flax, etc. Investigations on the physiological diseases of apples and pears were on a much reduced scale; but in the entomological field the outstanding feature was the attention given to the new insecticides D.D.T. and 666. A large-scale programme of investigation on the use of D.D.T. for the control of agricultural and horticultural pests was carried out in co-operation with all the State Departments of Agriculture, and particularly promising results were obtained in the control of cattle tick, buffalo fly and certain household pests. Methods for the control of mosquitoes and house flies reached an advanced stage of development, and investigation of the pests of stored wheat was practically concluded with the development of effective measures for the control of infestations in the main types of temporary stores. Much success in particular attended the campaign, based on the Council's advice, against wheat weevil carried out by the Australian Wheat Board; while the work on the biological control of weeds and insect pests continued to show great promise; for example, that of St. John's wort by three species of *Hypericum* insects. Work on D.D.T. emulsions led to the development of a solvent naphtha emulsion which was used in field trials in 1944–45, mainly at 0·2 per cent D.D.T., and work on the control of cattle ticks included trials with D.D.T. sprays.

Animal health investigations covered pleuropneumonia of cattle, mastitis in dairy cattle, contagious abortion of cattle, and the bacterial oxidation of arsenic cattle-dipping fluids. Studies with phenothiazine continued, as well as investigations of the blowfly strike problem and biochemical studies on mineral metabolism of sheep. There was no break in the sequence of the long-term research projects concerned with the nutrition of the Merino sheep, and the results should now provide a rational basis for breeding policy. Drought feeding and metabolic studies, the supply of vitamin A to flocks during prolonged periods of drought, the study of the plant proteins which are the raw materials from which the sheep produces wool fleece, studies of minor element deficiencies, and especially copper deficiency, are other directions in which the Council is assisting this major Australian industry.

The Division of Soils continued with a wide programme of surveys and investigations, and the obstacle to rapid progress presented by the lack of experienced staff is now being removed by the training of new personnel. Field-work was turning increasingly to the relation of soils and land use. The Soil Chemistry Section, organised jointly with the Chemistry Department of the Waite Institute under single direction, devoted attention to the study of methods for the examination of soils, including the use of the Lundegårdh flame spectrum technique for the determination of exchangeable cations. The study of soil structure and water relations of soils formed the main activity of the Soil Physics and Mechanics Section, while in the Bacteriology Section the investigation of the nitrogen-fixing organisms of leguminous plants was the main line of research.

At the Commonwealth Research Station, Merbein, initial investigations on vegetable production were completed, particularly variety trials of tomatoes,

beans and carrots, while at the Irrigation Research Station, Griffith, work on the best methods of irrigation of both orchard and vegetable crops continued. Much of the work of the Division of Forest Products was again associated with the war effort; but the need for a more concentrated examination of timber utilization in Australia is recognized, and a series of lectures was prepared for a reconstruction training course for Service personnel proposing to enter the building trade. Wood structure, timber physics and mechanics, timber preservation and seasoning continued to receive attention, as well as the improvement of wood, particularly by gluing or impregnation with dimethylolurea.

The Food Preservation Division is to resume its investigations on the preparation and storage of chilled beef with particular attention to the loss of bloom, and work is also to be started on the rapid freezing of fruit and vegetables. Fundamental aspects of the metabolism of ripening and senescence of fruits were examined at the University of Sydney. Apparatus was designed for measuring the vapour pressure of dried foods, and heat transfer and evaporation from a wet surface under still air conditions; investigations on *Clostridium botulinium* and on the resistance of this and other bacterial spores to heat were continued. The relation between mould growth and the activity of water in fruit cake, the development of ascorbic acid in processed foods on prolonged storage and fundamental studies on the oxidation of ascorbic acid in fruit and vegetable tissue suspensions were initiated. The Division of Fisheries was able to expand its work somewhat.

The Division of Metrology continued to assist production directorates of the Ministry of Munitions and industrial organisations concerned with defence, in matters relating to inspection, design and examination of gauges, measuring equipment and precision tool-room equipment. The Division of Electrotechnology concentrated largely on confidential defence investigations, but is now considering the resumption of normal work. Its future programme is likely to be influenced by the recent formation of an Electrical Research Board. The programme of research on tropic proofing and the scope of climatic and durability tests on telecommunication materials and communications have been considerably extended. The Physics Division is also planning to extend its long-range and fundamental research; among work carried out during 1944–45 were studies of the optimum visual conditions for radar operators, the photometry of a new type of searchlight, the control and measurement of humidity in connexion with tropic proofing of service equipment, the design of an instrument for the accurate and rapid measurement of hæmoglobin for 'blood bank' work, and fundamental work on the physics of wool fibres. Aeronautical investigations have included studies of the effects of turbulence on the size, state and stability of the boundary layer formed on the surface of solid bodies moving through air, the strength and stability of plywood construction, a mathematical study of the vibration characteristics of an engine-propeller – cooling-fan combination, powder metallurgy, welding of steel tubing and fatigue failures.

In the Division of Industrial Chemistry, a Section of Chemical Physics has been established at Melbourne. The Minerals Utilization Section has perfected a method for the production of the special grade of rare-earth oxides required for polishing optical lenses and prisms. The Cement Section is investigating the deterioration of concrete through expansive reaction between aggregates and cement, and in the Biochemistry Section the development of depilatory paints less harmful to wool than the lime-sulphide paint now used, the wool-loosening action of ammonia, proteolytic enzymes and the production of 2 : 3-butylene glycol by fermentation have received attention. The separation of minerals by flotation, physico-chemical characteristics of acridine drugs and surface areas of solids have been studied by the Physical Chemistry Section. The Organic Chemistry Section was also concerned with the production of butadiene from 2 : 3-butylene glycol obtained by fermentation, and continued work on the exudation of mannitol from *Myoporum platycarpum*, synthetic resin adhesives and aniline-formaldehyde resins. In the Chemical Engineering Section pilot-plant trials were conducted of the Fremey-Lipson process rendering woollen goods resistant to felt, and of an improved process for the manufacture of rare-earth hydroxides from monazite. The general basic attack on problems associated with friction, lubrication, bearings and wear continued, including the mechanism of boundary lubrication, effect of abrasives on wear, the development of a soluble extreme-pressure cutting and drawing lubricant, the lubrication between a journal and a bearing and the behaviour of pure metals.

THE GEOMETRY OF NUMBERS

THE meeting of the London Mathematical Society on December 19, 1946, took the form of a symposium on the geometry of numbers, arranged by Prof. H. Davenport. Prof. E. C. Titchmarsh, president of the Society, was in the chair.

In his introductory remarks, Prof. Davenport outlined the nature of the subject. It consists in interpreting geometrically questions in the theory of numbers, making use of points with integral co-ordinates, either in the plane, or, more generally, in an n-dimensional space. The system of all points with integral co-ordinates is called the *standard lattice*. The general homogeneous linear transformation, or affine transformation, of the standard lattice gives a *general lattice*. Thus the points of a general lattice in n-dimensional space are the points $(x_1, \ldots, x_n)$, where $x_1, \ldots, x_n$ are linear forms:

$$x_1 = a_{11}u_1 + \ldots + a_{1n}u_n$$
$$\ldots\ldots\ldots\ldots\ldots\ldots$$
$$x_n = a_{n1}u_1 + \ldots + a_{nn}u_n$$

in n variables $u_1, \ldots, u_n$, which take all integral values. The determinant of the coefficients a_{ij} is called the determinant of the lattice, and measures the density with which the lattice points are distributed in space (the density being inversely proportional to the determinant).

Many questions in the theory of numbers can be expressed in the form: Does a particular region contain a lattice point, or under what conditions is this the case? This geometrical approach led Minkowski to many important theorems. It is also valuable in suggesting new and interesting questions, even when it does not provide any means for answering them. Two of the three topics discussed later are, in fact, treated by other methods.

Mr. C. A. Rogers spoke on his recent work[1] on a theorem of Hlawka. This theorem is a partial con-

verse of the fundamental theorem of Minkowski, which asserts that any convex body in n-dimensional space, which is symmetrical about the origin of co-ordinates O, and has volume greater than 2^n, contains a point other than O of every lattice of determinant 1. Hlawka's theorem, in its most fundamental form, states that if any body (whether convex or not) has volume less than 1, then there exists a lattice of determinant 1 such that no lattice point, except possibly O, lies in the body. Mr. Rogers gave a simple proof of this theorem, restricting himself to the two-dimensional case for simplicity. We are given a bounded region in the plane, of area A less than 1. Let p be a large prime, and consider the lattice of points (x, y) with

$$x = u/\sqrt{p}, \quad y = (su + pv)/\sqrt{p},$$

where s is fixed, and u, v take all integral values. This lattice has determinant 1. We give s the values $0, 1, \ldots, p-1$, and suppose that each of the lattices has a point other than O in the region. It can be proved that these p points are all different. On the other hand, the total number of points of all the lattices in the region is easily found to be asymptotically pA for large p. Since $A < 1$, this is impossible, and so one at least of the lattices satisfies the requirement of having no point, except possibly O, in the region.

Dr. H. Heilbronn spoke about some recent joint work with Prof. Davenport on a problem to which they had been led by considerations in the geometry of numbers. The problem was to find two lattice points in a given plane lattice, say (X_1, Y_1) and (X_2, Y_2), which generate the lattice, and for which $X_1 Y_2$ is numerically small. Two such points would be, in a certain sense, each near one of the two co-ordinate axes. Expressed analytically, the problem becomes that of investigating the minimum of a bilinear form :

$$B = (\alpha x + \beta y)(\gamma z + \delta t),$$

when x, y, z, t take all integral values which satisfy the condition $xt - yz = \pm 1$. The results are as follows[2]. If $\Delta = |\alpha\delta - \beta\gamma|$, one can always satisfy $|B| \leqslant 2\Delta/(5+3\sqrt{5})$. If certain special forms are excluded (namely, those equivalent to $(x + \theta y)(z + \theta' t)$, where θ and θ' are $\frac{1}{2}(-1 \pm \sqrt{5})$), this can be improved to $|B| \leqslant \Delta/(4+2\sqrt{2})$. If more special forms are excluded, this can be further improved to $|B| \leqslant \Delta/(3 + 3\sqrt{2})$. But this inequality cannot be further improved by similar exclusions. There is a striking contrast with Markoff's results on the minimum of an indefinite quadratic form $(\alpha x + \beta y)(\gamma x + \delta y)$. There Markoff established the existence of an infinite sequence of possible minima. In the present problem, the first two possible minima of the bilinear form correspond to those of a quadratic form, but the third does not.

Prof. Davenport gave the third talk, which was on another joint paper[3] with Dr. Heilbronn. Let $Q(u_1, \ldots, u_r)$ be an indefinite quadratic form in r variables. It has been conjectured for many years that if $r \geqslant 5$, such a form takes arbitrarily small values for an infinity of integral values of the variables. If the form has rational coefficients, this is true, since it then represents zero infinitely often. The general conjecture has an interpretation in the geometry of numbers. It is that the region of r dimensional space defined by

$$|x_1^2 - x_2^2 \pm x_3^2 \pm \ldots \pm x_r^2| < 1,$$

where $r \geqslant 5$, contains a point other than O of *every* lattice. In the language of Mahler, this region is of 'infinite type'.

A special case of the conjecture was proved by Chowla in 1934, namely, when $Q = \lambda_1 u_1^2 + \ldots + \lambda_r u_r^2$ and when $r \geqslant 9$. In the present work the result is proved for this particular form when $r \geqslant 5$. The proof uses a modification of the powerful methods created by Hardy and Littlewood for the treatment of problems in additive number-theory.

Prof. L. J. Mordell expressed appreciation of the talks, and said that the work of Mr. Rogers was particularly interesting in view of the complication of Hlawka's original proof, and of the deep ideas associated with the theorem by Siegel, in his recent proof in the *Annals of Mathematics*. Mr. Rogers had shown the value of a new and elementary approach to an apparently difficult theorem.

[1] *Ann. Math.*, in the press.
[2] *Quart. J. Math.*, in the press.
[3] *J. London Math. Soc.*, in the press.

COMPLETE DOCUMENTATION*

By Dr. S. C. BRADFORD

THIS Conference is important historically, because it marks the beginning of a second stage in the progress of documentation. In the past, our main endeavour has been directed to bring about the collaboration of documentary agencies in the single task of making accessible the scattered records of thought and achievement, especially in science and technology, until to-day more decimally classified references are produced than different papers abstracted. But, as the result of statistical investigations, made in the main by the British National Section, we have come to see that this alone will not suffice to produce a tolerably complete index to the records of human endeavour. Half the records are overlooked by the existing abstracting and indexing agencies. We need a means of covering all this literature. The means has been discovered. Its promotion has commenced, and this begins a second stage in our activities.

Statistical analyses have been made of the whole intake of the Science Library, London, not merely of three per cent samples. The results are for that reason the more reliable, although there is still room for more research, for which financial aid would be desirable.

The investigations were divided into four parts : (i) It was established that about ¾ million useful scientific and technical papers are recorded every year in an aggregate of some 15,000 useful scientific periodicals, while 300 abstracting and indexing periodicals publish also ¾ million abstracts, or references. But these abstracts, or references, relate to only ¾ million different papers. So that more than half the useful discoveries and inventions are recorded, only to be buried on the library shelves.

(ii) This general analysis was confirmed by the examination of the literature of certain definite subjects. The details of the examination of electrical engineering literature show that only 11,500 different papers on this subject, out of an annual output of 24,000, are covered by a yearly total of 45,000

* Synopsis of a paper read at the sixteenth International Conference of the International Federation for Documentation at Paris, November 4–9, 1946.

abstracts, or references. These tests indicated also the basic reasons for this imperfection, which are: (*a*) individual abstracting agencies concentrate upon the periodicals devoted to their special subjects, together with a few of those the fields of which are closely allied to these subjects, and thus they miss the articles on their special subjects which occur in other periodicals the scopes of which are less closely related to them; and (*b*) abstracting agencies often ignore books, pamphlets, separate reports and patent specifications.

(iii) The actual scattering of articles on a given subject throughout the mass of periodical literature was investigated. This scattering is the necessary consequence of the fact that every branch of science is related in some degree to every other branch of science, so that a periodical on any branch of science may contain, from time to time, a paper which is of interest from the point of view of any other science. The actual law of scattering has been deduced, both from theoretical consideration, and from investigation of the actual articles indexed on a given subject. This law shows that it is practically impossible for an abstracting agency, acting alone, to pick up more than about half the articles published on its special subject.

(iv) The actual occurrence of these scattered articles, in the estimated quantity, was proved by a bulk experiment with the collaboration of the abstractors of a large abstracting bureau.

These experiments show conclusively that, somehow, every useful article in every useful periodical must be dealt with as it appears. There are two different ways of accomplishing this task. Either we could create a new organisation to index, or to abstract, each useful article in each useful periodical, independently of the subject of the article; or the useful periodicals could be divided into groups, according to the subjects treated by existing abstracting agencies, and these agencies should undertake to pass on the articles not within their scopes to the agencies who should be interested in their subjects.

The former method would be utterly uneconomic, because it would duplicate, without any adequate reason, the work of the existing skilled and experienced abstracting bureaux. The latter method needs much less additional expense. No interference is involved with the internal machinery of any abstracting agency. Each can continue to deal with and abstract as many periodicals as it desires and to publish its abstracts in any format, provided only that it passes on the articles not within its own scope.

The application of this principle has been commenced in Great Britain. A committee of important abstracting agencies has been formed, which has accepted the principle, and an agreement has been made by two of the most important agencies, British Abstracts and Science Abstracts, to work together so far as possible in this way. Bibliography is unforgettably indebted to Dr. J. A. Wilcken, secretary of the British Committee, for his outstanding services in this work.

The comprehensive indexing of books and other separate publications is essentially a matter for librarians and can best be achieved by improving the accessions lists of the national libraries of each country. In this way we can certainly achieve complete documentation.

[This plan was adopted unanimously by the Council of the International Federation for Documentation, and a small international committee was appointed to promote it.]

SCIENCE MASTERS' ASSOCIATION

ANNUAL MEETING

THE forty-fourth annual meeting of the Science Masters' Association was held at the Imperial College of Science and Technology, London, during January 1–3; and once again, in spite of the fact that the previous meeting was held only last Easter, the attendance was large, and an excellent programme of lectures and visits to works marked another successful gathering. There was also the usual exhibition of books and apparatus by the leading publishers and manufacturers of scientific apparatus, and the customary exhibit of apparatus devised and constructed by members themselves, and also one of graphic material of use in teaching. The Association has now returned to its old practice of holding its annual meeting during the Christmas holiday.

Giving the presidential address, Lord Horder spoke on the "Place of Science in Teaching", approaching this in the free and interesting spirit of one who saw things in their wider setting, and presenting some sound advice to his audience. His address, which sparkled at times with some keen wit and was illustrated by apposite anecdote, took three aspects of the subject: the pupil, the matter taught, and the teacher. The most important aspect is the pupil, who is still, it must be emphasized, a child, still half-savage, with recurring moods of self-exhibitionism and fantasy which can last well into undergraduate life and which must neither be unduly encouraged nor neglected. The task of the teacher is to help the child on the road to the full development of personality; he cannot create such personality.

The matter taught must be free from domination by the examination spectre which stultifies curiosity and impairs receptive power, and must avoid undue emphasis on application at the expense of first principles. Through the study of science the youthful mind can acquire habits of clear thinking and direct expression which lead it to become a joy to itself and a source of benefit to others.

The attitude of the teacher is of fundamental importance to the efficiency of his teaching. This attitude must be animated by two ideals: first, that science must be free and self-contained, owing subservience to neither Church, State nor the pressure of economic adjustment; secondly, the discoveries of science must be used for the benefit of humanity. The present troubles of the world are due to too little science, not too much. To drive science underground by the cessation of research would be to repeat all the evils of the Dark Ages. What is important is that we retain sufficient control to drive the machine and not allow it to drive us. Upon these ideals it is important that science teachers should stand firm. The chief aim of science is truth, and truth grows as does a living plant, which suffers as much from forcing as it does from neglect.

The Association was again fortunate in having lectures from men of science of eminence in their own fields. Mr. E. J. Bowen spoke on "Elementary Wave-Mechanics", presenting a treatment which opened the way to deriving ideas of great value in chemistry teaching; Sir Edward Salisbury discussed "The Changing Flora of Britain", describing the nature of large-scale changes since the Glacial period; Sir George Thomson spoke on "Atomic Energy in Peace and War", ending with a stimulating consideration of present problems; Prof. J. Z. Young took the

subject of "Use, Effort and the Powers of Life", and dealt with the problem of treating in biology the self-preserving powers of organisms; and Dr. G. A. Jones discussed "High Speed Cinematography", accompanying his lecture with demonstrations of modern devices used to synchronize flash and exposure.

At the business meeting of the Association it was announced that the Association had been invited to hold its next annual meeting at the University of Sheffield. Prof. Irvine Masson, vice-chancellor of the University of Sheffield, has consented to serve as president for this year. Prof. E. N. da C. Andrade, last year's president, was elected an honorary member according to custom, and this tribute was also paid to the work for the Association of Mr. F. Fairbrother, the retiring membership secretary. Mr. H. F. Broad (Leighton Buzzard) was elected membership secretary in succession to Mr. Fairbrother; and in succession to Mr. A. E. E. McKenzie (chairman) and Mr. E. Lucas, who retired from the Committee, the meeting elected Mr. J. Lambert (King Edward School, Birmingham) and Mr. H. Jennings (Liverpool College). Mr. E. H. Coulson was re-elected treasurer.

A. E. Bell

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, January 20

Manchester Literary and Philosophical Society (in the Reynolds Hall, College of Technology, Manchester), at 5.30 p.m.—Prof. J. M. Meek: "Lightning and Spark Discharges".*

Royal Anthropological Institute (joint meeting with the Royal Geographical Society, at Kensington Gore, London, S.W.7), at 5.30 p.m.—"The Ashanti Social Survey, 1945–46".

King's College, Strand, London, W.C.2, at 6 p.m.—Prof. S. J. Davies: "Gas Turbines and their Prospects" (Lecture on behalf of the Institute of Marine Engineers).*

Tuesday, January 21

Society of Chemical Industry, Agriculture Group (in the Physical Chemistry Lecture Theatre, Royal College of Science, South Kensington, London, S.W.7), at 2.30 p.m.—Dr. F. H. Malpress: "The Use of Hormones in Animal Husbandry".

Society of Dyers and Colourists, Leeds Junior Branch (in the Colour Chemistry and Dyeing Department, The University, Leeds), at 4 p.m.—Dr. F. H. S. Curd: "The Chemotherapy of Malaria".

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Dr. C. D. Darlington, F.R.S.: "The Physiology of Chromosomes". (Subsequent lectures on January 28 and February 4.)

Eugenics Society (at the Royal Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Symposium on "Relation of Intelligence to Fertility" (Speakers: Sir Alexander Carr Saunders, Sir Cyril Burt and Dr. J. H. Fraser Roberts).

Institution of Electrical Engineers, Radio Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Radio versus Line for Communication Systems" (to be opened by Mr. A. H. Mumford).

Sheffield Metallurgical Association (at 198 West Street, Sheffield), at 6.30 p.m.—Annual General Meeting.

Society of Dyers and Colourists, Huddersfield Section (at Field's Café, Huddersfield), at 7.30 p.m.—Dr. T. Richardson and Mr. E. R. Wiltshire: "The Package Dyeing of Cotton by the Pigment Method".

Institute of Physics, Scottish Branch (at the University, Edinburgh).—Prof. P. I. Dee, F.R.S.: "Photography of Atomic Tracks".

Wednesday, January 22

Institution of Post Office Electrical Engineers (at Faraday Building, 9th Floor, South Block, Knightrider Street, London, E.C.4), at 5 p.m.—Mr. A. Hudson, Mr. E. A. Smith and Mr. F. S. Hyatt: "Auto. Exchange Maintenance".

Physical Society, Low-Temperature Group (at the Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Dr. M. Ruhemann: "The Separation of Oil Gases".

Royal Meteorological Society (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Annual General Meeting; Mr. G. Manley: "The Geographer's Contribution to Meteorology".

Royal Society of Arts (at John Adam Street, Adelphi, London, W.C.2), at 5 p.m.—Sir Claude Gibb: "Gas Turbines".

Institution of Electrical Engineers (joint meeting of the Transmission and Measurements Sections, at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Discussion on "Switchgear Alarms and Indications" (to be opened by Mr. T. S. Andrew and Mr. T. R. Reyner).

Society of Dyers and Colourists, Midlands Section (at the Victoria Hotel, Nottingham), at 7 p.m.—Mr. C. S. Turner: "Shortcomings of the Dyeing Industry as seen by the Launderer, Dry-cleaner and Garment Dyer".

Thursday, January 23

Chemical Society, Liverpool Section (in the Chemistry Lecture Theatre, The University, Liverpool), at 5 p.m.—Prof. H. A. Krebs: "Metabolic Cycles".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Major Gavin Maxwell; "The Basking Shark (*Celorhinus maximus*) of the Hebrides"; Dr. Hans Grüneberg: "The Significance of Coat Colour in Mammals".

Royal Institution (at 21 Albemarle Street, London, W.1), at 5.15 p.m.—Prof. H. W. Melville, F.R.S.: "The Chemistry of High Polymers". (Subsequent lectures on January 30 and February 6.)

Royal Statistical Society (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Discussion on "Statistics and the Statistician in Industry" (to be opened by Mr. H. T. Weeks).

Institution of Electrical Engineers, Installations Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. V. J. Francis and Mr. W. R. Stevens: "The High-Pressure Mercury-Vapour Discharge and its Applications".

Chemical Society, South Wales Section (joint meeting with the University College of Swansea Chemical Society, in the Chemistry Lecture Theatre, University College, Swansea), at 6 p.m.—Mr. E. J. Bowen, F.R.S.: "The Absorption of Light".

Royal Institute of Chemistry, Manchester Section (at the Engineers' Club, Albert Square, Manchester), at 7 p.m.—Prof. T. P. Hilditch, F.R.S.: "Fat Shortages and Fat Substitutes".

Chemical Society, Society of Chemical Industry and Royal Institute of Chemistry, Edinburgh and East of Scotland Sections (at the North British Station Hotel, Edinburgh), at 7.30 p.m.—Mr. F. A. Scholefield: "Edmund Knecht" (Society of Chemical Industry Jubilee Memorial Lecture).

Friday, January 24

Royal Astronomical Society (at Burlington House, Piccadilly, London, W.1), at 4.30 p.m.—Geophysical Discussion on "Atmospheric Oscillations" (to be opened by Prof. S. Chapman, F.R.S.).

Institution of Electrical Engineers, Measurements Section (at Savoy Place, Victoria Embankment, London, W.C.2), at 5.30 p.m.—Mr. H. Cobden Turner and Mr. G. M. Tomlin: "The Application of Electrical Technique to the Service of some other Industries".

Institution of Mechanical Engineers (at Storey's Gate, St. James's Park, London, S.W.1), at 5.30 p.m.—Dr. F. T. Barwell and Mr. J. C. W. Humphrey: "Materials New to Engineering".

Society of Dyers and Colourists, Scottish Section (at St. Enoch Hotel, Glasgow), at 7 p.m.—Mr. G. G. Simpson: "The Selection of Dyes for Covering Faded Garments".

Chemical Society, Aberdeen Section (in the Chemistry Department, Marischal College, Aberdeen), at 7.30 p.m.—Dr. D. P. Cuthbertson: "Recent Advances in our Knowledge of the Metabolism of Proteins and Amino Acids".

Saturday, January 25

Biochemical Society (at the British Postgraduate Medical School, Ducane Road, London, W.12), at 11 a.m.—Scientific Papers and Demonstrations.

British Sound Recording Association (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 4.15 p.m.—Conference on "Sound Recording".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Graduate Field Research Workers to investigate problems connected with the growth of forest trees in relation to soil and site factors—The Director, Imperial Forestry Institute, The University, Oxford (January 25).

Lecturer in the Department of Mechanical Engineering—The Principal, Birmingham Central Technical College, Suffolk Street, Birmingham (January 25).

Lecturer in Chemistry, and a Lecturer to teach Electrical and/or Civil and Mechanical Engineering, in the Plymouth and Devonport Technical College—The Director of Education, Cobourg Street, Plymouth (January 25).

Assistant Teacher to be responsible for Agricultural Science, Animal and Soil Husbandry—The Chief Education Officer, County Offices, Aylesbury, Bucks. (January 29).

Lecturer in Mechanical and Electrical Engineering in the Mining Department of the Denbighshire Technical College, Wrexham—The Director of Education, Education Offices, Ruthin (January 31).

Assistant Masters in H.M. Dockyard Schools—The Director, Education Department, Admiralty, London, S.W.1 (January 31).

Technician for research laboratory workshop—The Secretary, Barnato Joel Laboratories, Middlesex Hospital, London, W.1 (February 1).

CHEMISTS (men and women, temporary) at various research and development establishments of the Ministry of Supply—The Secretary, Ministry of Supply (Est.5.B.2), Room 828, Adelphi, London, W.C.2, quoting 'Chem/Gen' (February 1).

LECTURER IN SOCIAL ANTHROPOLOGY—The Registrar, The University, Oxford (February 7).

ASSISTANT LECTURER (Grade III) in the Department of Biochemistry—The Registrar, The University, Liverpool (February 7).

ECONOMIST (with a good degree and experience of economic research), and a SOCIOLOGIST (with a good degree and experience of sociological or anthropological research), in connexion with a survey of factors bearing on the problem of nutrition in the Gambia—The Secretary, Colonial Social Science Research Council, Palace Chambers, Bridge Street, London, S.W.1 (February 10).

GEOLOGIST-GEOPHYSICIST, or a GEOLOGIST experienced in electrical methods of geophysical work, for the Uganda Geological Survey—The Director of Recruitment (Colonial Service), Colonial Office, 15 Victoria Street, London, S.W.1 (February 12).

LECTURER IN PSYCHOLOGY at the University of Tasmania—The Agent-General for Tasmania, Golden Cross House, Charing Cross, London, W.C.2 (February 15).

LUCAS CHAIR IN THE PRINCIPLES OF ENGINEERING PRODUCTION—The Secretary, The University, Edmund Street, Birmingham 3 (February 15).

SENIOR CHEMIST to take charge of corrosion research on metal coatings with or without organic finishes, an ELECTRO-CHEMIST for original research on the deposition of alloy coatings, an ANALYTICAL CHEMIST with experience in analysis of metals and alloys, and a LIBRARIAN (male or female) to take charge of scientific library and information service—The Director, Tin Research Institute, Fraser Road, Greenford, Middx. (February 28).

ASSISTANT DIRECTORS in the Imperial Agricultural Bureaux of Soil Science, of Dairy Science, of Horticulture and Plantation Crops, and of Pastures and Forage Crops (including Field Crops)—The Secretary, Imperial Agricultural Bureaux, 2 Queen Anne's Gate Buildings, London, S.W.1 (March 1).

UNIVERSITY LIBRARIAN AND KEEPER OF THE BROTHERTON COLLECTION—The Registrar, The University, Leeds (March 10).

PROFESSOR OF DAIRYING—The Registrar, The University, Reading (March 17).

TOPOGRAPHICAL ENGINEER by the Government of Iraq for the Directorate General of Surveys—The Crown Agents for the Colonies, 4 Millbank, London, S.W.1, quoting M.N.17249.

JUNIOR TECHNICIAN in a physical research laboratory—The Administrative Officer, National Institute for Medical Research, Hampstead, London, N.W.3.

ASSISTANT MASTER to teach General Science and Mathematics up to Matriculation standard—The Principal, Dartford County Technical College, Essex Road, Dartford, Kent.

HEAD OF THE PHYSICS DEPARTMENT—The Governing Body, Northern Polytechnic, Holloway, London, N.7.

LABORATORY ASSISTANT (man) at Coopers Hill Emergency Training College, Englefield Green, Surrey—The Education Officer (Estab./2), County Hall, Westminster Bridge, London, S.E.1.

TEXTILE TECHNOLOGIST in India—The Secretary, Indian Jute Mills Association Research Institute, Imperial Institute, South Kensington, London, S.W.7.

DIRECTOR OF RESEARCH—The Secretary, British Leather Manufacturers' Research Association, 8 St. Thomas Street, London, S.E.1.

RESEARCH ASSISTANT with experience of ultra-violet absorption spectroscopy—The Secretary, Royal Cancer Hospital (Free), Fulham Road, London, S.W.3.

DEPUTY HEAD OF THE LIBRARY AND INFORMATION BUREAU, and a PHYSICIST (young) for work on the application of physics and mathematics to problems of a mechanical nature—The Director, British Cotton Industry Research Association, Shirley Institute, Didsbury, Manchester.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Freshwater Biological Association of the British Empire. Fourteenth Annual Report for the Year ending 31st March 1946. Pp. 54. (Ambleside: Freshwater Biological Association of the British Empire, 1946.) 1*s.* 6*d.* [69

Northern Ireland: its History, Resources and People. By Hugh Shearman. Pp. 32 + 12 plates. (London: Government of Northern Ireland, 1946.) Free. [69

University of Sheffield. Adult Education in H.M. Forces: Work of the Sheffield Regional Committee, 1940–1946. Pp. ii + 17. Record of War Work, 1939–1945. Pp. 24. (Sheffield: The University, 1946.) [99

City and Guilds of London Institute. Report of the Council to the Members of the Institute for the Year 1945. Pp. 61. (London: Gresham College, 1946.) [99

British Museum (Natural History). Report on Cretacea stranded on the British Coasts from 1933 to 1937. By Dr. F. C. Fraser. Pp. 56 + 7 maps. (London: British Museum (Natural History), 1946.) 7*s.* 6*d.* [119

Wool Wax Alcohols in Industry. By E. S. Lower. Pp. 59. (Goole: Croda, Ltd., Snaith, 1946.) [910

Council for the Preservation of Rural England. Annual Report, 1946. Pp. 36. (London: Council for the Preservation of Rural England, 1946.) [910

The New World—and the Mass Mind. By Richard Tatham. (Social Science Series, No. 1). Pp. 16. (London: Social Science Association, 1946.) 6*d.* [910

Department of Scientific and Industrial Research. Interim Memorandum on District Heating. By the District Heating Sub-Committee of the Heating and Ventilation (Reconstruction) Committee of the Building Research Board. Pp. 10. (London: H.M. Stationery Office, 1946.) 3*d.* net. [910

Scientific Proceedings of the Royal Dublin Society. Vol. 24 (N.S.), No. 15: The Magnetic Properties of the Serpentine Deposits in the Slishwood Gap, County Sligo, Ireland. By W. E. Seeds and Dr. J. H. J. Poole. Pp. 135–148 + plate 11. 2*s.* Vol. 24 (N.S.), No. 16: Award of the Boyle Medal to the late Prof. Thomas J. Nolan. Report of the Committee on Science and its Industrial Applications. Pp. 149–150. n.p. (Dublin: Hodges, Figgis and Co., Ltd.; London: Williams and Norgate, Ltd., 1946.) [910

Microchemistry and its Applications. By Ronald Belcher. Pp. 52. (London: Royal Institute of Chemistry, 1946.) [910

Soil Metabolism. By Dr. J. H. Quastel. Pp. 22. (London: Royal Institute of Chemistry, 1946.) [910

Other Countries

Conseil Permanent International pour l'Exploration de la Mer. Bulletin statistique des Pêches maritimes des Pays du nord et de l'ouest de l'Europe. Vol. 28, pour l'année 1938. Rédigé par Sir D'Arcy Wentworth Thompson. Pp. x + 49. 3 kr. Annales biologiques. Vol. 1, 1939–41. Rédigé par H. Blegvad. Pp. 190. 10 kr. Bulletin hydrographique pour les années 1938 et 1939. Pp. iv + 212. 10 kr. (Copenhague: Andr. Fred. Høst et fils, 1943–1944.) [286

Development and Welfare in the West Indies. Bulletin No. 30: The Fisheries of the Windward and Leeward Islands. Report by Dr. H. H. Brown. Pp. 98. (Bridgetown: Advocate Co., Ltd., 1946.) 30 cents. [29

Fondation Universitaire. Vingt-cinquième Rapport Annuel, 1944–1945. Pp. 112. (Bruxelles: Fondation Universitaire, 1946.) [29

Annals of the New York Academy of Sciences. Vol. 46, Art. 7: Non-Projective Personality Tests. By Harold A. Abramson, Keeve Brodman, Harold J. Harris, George G. Killinger, Bela Mittelmann, Zygmunt A. Piotrowski, David Rapaport, Roy Schaefer, Martin Scheerer, David Wechsler, Arthur Weider, Harold G. Wolff, Edith Wladkowsky and Joseph Zubin. Pp. 531–678. (New York: New York Academy of Sciences, 1946.) 1.75 dollars. [40

A Strain Theory of Matter. By Prof. M. Hessaby. Pp. iv + 90. (Tehran: Taban Press, 1946.) [40

Bulletin of the American Museum of Natural History. Vol. 87, Article 1: Fossil Penguins. By George Gaylord Simpson. (Publications of the Scarritt Expeditions, No. 33.) Pp. 100. Vol. 87, Article 2: Survey of Contemporary Knowledge of Biogeochemistry, 1, Isotopic Phenomena in Biogeochemistry. By Martin D. Kamen. Pp. 101–138. Vol. 86, Article 8: Amphibians and Reptiles of the Río Chucunaque Drainage, Darien, Panama, with Notes on their Life Histories and Habits. By C. M. Breder, Jr. Pp. 375–436 + plates 42–60. (New York: American Museum of Natural History, 1946.) [69

Food and Agriculture Organization of the United Nations. First Annual Report of the Director-General to the FAO Conference. Pp. iv + 45. World Food Survey. Pp. 39. Proposals for a World Food Board. Prepared for submission to the Second Session of the Conference of the Food and Agriculture Organization, Copenhagen, Denmark, 2 September 1946. Pp. iii + 12. (Washington, D.C.: Food and Agriculture Organization of the United Nations, 1946.) [99

Smithsonian Institution: Freer Gallery of Art. Oriental Studies, No. 3: A Descriptive and Illustrative Catalogue of Chinese Bronzes acquired during the Administration of John Ellerton Lodge. Compiled by the Staff of the Freer Gallery of Art. (Publication 3805.) Pp. v + 108 + 50 plates. (Washington, D.C.: Government Printing Office, 1946.) [99

U.S. Department of Agriculture. Leaflet No. 147: House Ants. By E. A. Back. Revised edition. Pp. 8. (Washington, D.C.: Government Printing Office, 1946.) 5 cents. [99

The First Hundred Years of the Smithsonian Institution, 1846–1946. By Webster P. True. Pp. viii + 64 + 41 plates. (Washington, D.C.: Smithsonian Institution, 1946.) [99

Union of South Africa: Department of Mines, Geological Survey. Memoir No. 40: The Geology of the Messina Copper Mines and Surrounding Country. By P. G. Söhnge. Pp. 280 (95 plates). 21*s.* Memoir No. 41: A Geochemical Survey of the Underground Water Supplies of the Union of South Africa, with particular reference to their Utilisation in Power Production and Industry. By Dr. G. W. Bond. Pp. iv + 216. 10*s.* (Pretoria: Government Printer, 1945–1946.) [99

U.S. Department of Agriculture, Miscellaneous Publication No. 601: Collection and Preservation of Insects. By P. W. Oman and Arthur D. Cushman. Pp. iii + 42. (Washington, D.C.: Government Printing Office, 1946.) 15 cents. [99

Smithsonian Miscellaneous Collections. Vol. 106, No. 10: A Re-examination of the Fossil Human Skeletal Remains from Melbourne, Florida, with Further Data on the Verdo Skull. By T. D. Stewart. (Publication 3854.) Pp. ii + 28 + 8 plates. (Washington, D.C.: Smithsonian Institution, 1946.) [99

Imperial Council of Agricultural Research. Miscellaneous Bulletin No. 64: Standard Methods for the Analysis of Ghee. Report of a Special Committee appointed to suggest *inter alia* Standard Methods for the Analysis of Ghee. Pp. 9. (Delhi: Manager of Publications, 1946.) 6 annas; 7*d.* [119

Memoirs of the Numismatic Society of India. No. 1: The Technique of Casting Coins in Ancient India. By Prof. Birbal Sahni. Pp. iv + 68 + 7 plates. (Bombay: Numismatic Society of India, 1945.) [269

Report of the South African Museum for the Year ended 31st December 1945. Pp. 18. (Pretoria: South African Museum, 1946.) [910

Commonwealth of Australia: Council for Scientific and Industrial Research. C.S.I.R., 1945. By G. Lightfoot. Pp. 98 (20 plates). Bulletin No. 190: Foundry Sand Resources of South Australia. By H. S. Cornelius and H. A. Stevens. Pp. 80 + 11 plates. (Melbourne: Government Printer, 1945.) [910

Museums Trustees of Kenya. Annual Report for the Year 1945 of the Museums Trustees of Kenya and of the Coryndon Memorial Museum, Nairobi. Pp. 16. (Nairobi: Coryndon Museum, 1946.) [910

National Geological Survey of China. Geological Memoirs, Series A, No. 20: On Major Tectonic Forms of China. By T. K. Huang. Pp. vi + 165 + 9 plates. (Chungking: National Geological Survey of China, 1945.) [910

Nyasaland Protectorate. Annual Report of the Forestry Department for the Year ended 31st December 1945. Pp. 16. (Zomba: Government Printer, 1946.) [910